1

This document has been approved for public release and sale; its distribution is unlimited.

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

1

AFIT/GEM/DEV/91S-15

BUILDING A FOREIGN MILITARY SALES CONSTRUCTION DELIVERY STRATEGY DECISION SUPPORT SYSTEM

THESIS

Deven R. Volk, Captain, USAF

AFIT/GEM/DEV/91S-15

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

AFIT/GEM/DEV/91S-15

BUILDING A FOREIGN MILITARY SALES
CONSTRUCTION DELIVERY STRATEGY
DECISION SUPPORT SYSTEM

THESIS

Presented to the Faculty of the School of Systems and

Logistics of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

Deven R. Volk, B.S.

Captain, USAF

September 1991

Acknowledgements

I would like to acknowledge those who were helpful to me during the course of this research. The entire staff in the Directorate of FMS Construction Engineers (CER) at HQ Air Force Logistics Command were the motivation to this research. They gave freely of their time to explore and discuss the complex world of foreign military sales. In particular, Rusty Meyers, Deputy Director, Ken Wichman, Chief, Saudi Division and Jim Hensley, Program Manager, Saudi Division, provided invaluable direction to this research. Together, they provided the corporate knowledge which was the foundation to the entire effort.

In addition to the CER staff, Bob Chambers, Pat Harris, and Tom Stevens, construction contractors supporting CER, provided experience from outside of the AF construction world which plays an integral part of FMS construction. Their candid and insightful observations guided many aspects of the research.

I would also like to thank Kathy Kowalski at the AFIT Library for expending an inordinate amount of time attempting to retrieve FMS construction information from the Defense Technical Information Center database.

My thesis advisor, Major Mike Duncan provided extreme patience (probably too much), invaluable criticism, and

English grammar expertise which pulled me through to the end of the entire process.

Finally, I wish to extend my heartfelt gratitude to Jody, my wife, and our wonderful neighbors. Jody sat quietly waiting, taking care of business, while the night lights burned. Neighbors came out of the woodwork to help several times during medical emergencies and provided the welcome backyard volleyball games to stimulate the brain cells.

Deven R. Volk

Table of Contents

Page

List of Figures

AFIT/GEM/DEV/91S-15

Abstract

This research builds a Decision Support System to help Air Force Logistics Command, Foreign Military Sales construction managers select a construction delivery strategy in support of weapon system sales to foreign countries. Delivery strategy options include the Corp of Engineers, Naval Facilities Engineering Command, private industry Architectural Engineering firms, the weapon system supplier, or the foreign country purchasing the weapon system. The parameters upon which the selection is made are program schedule, staffing requirements, weapon system development stage and design complexity, type of contract strategies selected, a customer assessment of foreign country requirements and existing conditions, and the ability to respond to construction program changes. The research discovered that as the program schedule is shortened, all parameters take on more critical characteristics. As the program schedule becomes longer, the parameters take on characteristics of standard construction practices. In the latter situation, more complex construction technology requirements may be prevalent in pushing the situation away from standard. Air Force policy supports the use of the COE or NAVFAC under more standard conditions. As conditions become less standard, private industry is preferred.

BUILDING A FOREIGN MILITARY SALES CONSTRUCTION DELIVERY STRATEGY DECISION SUPPORT SYSTEM

I. Introduction

Overview

Strengthening U.S. allies is one objective of the national defense strategy. This chapter discusses how a Foreign Military Sales (FMS) construction delivery strategy supports this objective. It also states the research objective, research questions to support the research objective, and the reason for a Middle East focus.

Background

The national defense strategy is to preserve the United States as a free and independent nation, with its people, values, and institutions secure. Secretary of the Air Force, Donald Rice, in a June 1990 White Paper titled 'Global Reach-Global Power', outlines Air Force objectives to support the national defense strategy. They are:

- Sustain Deterrence - Nuclear Forces
- Provide Versatile Combat Force - Theater Operations & Power Projection
- Supply Rapid Global Mobility - Airlift and Tankers
- Control the High Ground - Space & C3I Systems
- Build U.S. Influence - Strengthening Security Partners and Relationships. (39:5)

In response to the changing nature of Eastern Europe and the Soviet Union, Secretary Rice recognizes that "Extraordinary international developments over the last few years have created the potential for a significantly different security environment as we approach the beginning of the 21st century" (39:i). The foundation of our defense strategy is deterrence - deterrence based on a mix of nuclear and conventional forces, forward defense, power projection capabilities and strong allies. General Colin Powell, Chairman of the Joint Chiefs of Staff, in support of Secretary Rice's comment, observed, "We must remember how we got to this historic turning point in history - our systemic strength and the strength of our allies has gotten us here" (39:2).

Developing strong U.S. allies is integral to the national defense strategy and Air Force objectives. 'The Management of Security Assistance', published by the Defense Institute of Security Assistance Management (DISAM), indicates that strengthening allies is the focus of the U.S. Security Assistance (SA) program. "One of the primary methods used to carry out our foreign and national security policy has been and still remains the transfer of defense articles, defense services, military training, and economic assistance; or, stating it another way, by providing security assistance" (10:5).

In 'Global Reach - Global Power', Secretary Rice goes on to say,

> Security assistance provides the capability to enhance security conditions, strengthen security partners, and project U.S. influence to build democracies, with limited or no use of U.S. forces. The Air Force is well postured to contribute toward these national objectives. Security assistance allows us to influence events and protect national interests in areas where more visible means of intervention are not viable. (39:13)

Foreign Military Sales (FMS) is a significant SA program through which foreign countries can purchase defense articles from the U.S. Government (USG) (10:38). An integral aspect of defense article purchases is the construction component to support a weapon system. As modern weapon systems become more technologically advanced and complex, the facilities requirement becomes more critical to the operation of the weapon system (35;40;42).

HQ Air Force Logistics Command (AFLC), Directorate of FMS Construction Engineers (CER) is the AF construction program manager (CPM) for AFLC FMS programs and can be assigned by FMS program managers as CPM for non-AFLC FMS construction programs. As the CPM, CER is responsible for monitoring and reporting the progress of FMS construction programs to FMS program managers (25;40). This research assumes that CER has been assigned as the CPM for a particular FMS construction program.

In addition to the CPM, a design and construction agent (DCA) is assigned the responsibility to implement and manage the FMS construction program. DCA authority can be given to the Corp of Engineers (COE), the Naval Facilities

Engineering Command (NAVFAC) or CER. DCA selection is not a well defined process. Several Department of Defense (DOD) agencies can make the selection including the Office of the Secretary of Defense (OSD), the Defense Security Assistance Agency (DSAA), the principle organization through which SA programs are managed, or FMS program managers can select the DCA (11:300-1;25). This research assumes CER has been designated as the DCA for FMS construction programs.

CER is not adequately staffed to perform design and construction management activities. When CER is designated as the DCA, it must select a construction manager (CM) to perform the construction program functions of defining facility requirements, designing the facilities and performing construction management activities. The CM has the authority to enter into contracts with design and construction contractors to perform these functions (35;42).

With few exceptions, the COE and NAVFAC are designated as DCAs and CMs for the U.S. Air Force (USAF) Military Construction (MILCON) program by Public Law 97-214, July 12, 1982: Military Construction Codification Act (29:E-1.9). Both the COE and NAVFAC can use in-house capability or contract with private industry for design activities. Both typically hire construction contractors to perform construction activities.

MILCON DCA and CM responsibilities for the COE and NAVFAC do not extend to FMS construction. When CER is designated as DCA for a FMS construction program, it has the

option to either use the COE or NAVFAC or to select CM strategies other than the COE or NAVFAC. These additional CM choices include private architectural engineering (AE) firms, the weapon system supplier, the purchasing country or combinations of these choices. The CM, or combination of CMs chosen, are referred to as the construction delivery strategy. This research assumes that only one CM will be selected by CER as the construction delivery strategy. The construction delivery strategy will determine how successful CER is in meeting the objective of delivering quality facilities, on time, within budget, and to customer satisfaction (35;40;42).

Construction Delivery Strategy Selection. Construction is often one of the first physical activities to begin in a FMS program and may set the stage for the success of follow-on weapon delivery activities. The success of this initial visibility of U.S. management capability is important because impressions left with a foreign country can affect future diplomatic relationships. Selecting an appropriate construction delivery strategy is critical because the success of the entire FMS program can depend upon the construction program. A successful FMS program translates into better diplomatic relationships which supports the U.S. national defense strategy of building strong allies (35;40;42).

CER must evaluate several parameters to select a construction delivery strategy. It is not as simple as

determining technical requirements, pulling an applicable facility package off the shelf and installing it. According to Colonel Karsten Rothenberg, Director of CER, selecting a construction delivery strategy is a complex determination of political realities, foreign capabilities, weapon system conditions, and other parameters (40).

When presented with a FMS construction program, CER must gather information from many sources to develop a picture of the conditions faced by the FMS construction program. In essence, CER must conduct a situation analysis to determine initial conditions. The situation analysis focuses on parameters of a FMS construction program which, when properly monitored and managed, can ensure a successful construction program. CER must then select a construction delivery strategy alternative with the greatest probability of delivering facilities given these initial conditions (35;40;42).

Currently, CER has no established procedure to systematically conduct a situation analysis. The process is guided by the experience and knowledge of two or three managers in CER who travel extensively to manage current programs. Consequently, there is no assurance that the information gathered to evaluate these parameters is accurate or complete and that the best construction delivery strategy has been selected (35).

Research Objective

The objective of this research is to build a decision support system (DSS) to assist CER in the selection of FMS construction delivery strategies when assigned as the construction program manager and design and construction agent for FMS construction programs.

Research Questions

1. What are the parameters CER must evaluate to perform a situation analysis?

2. How can these parameters be used by CER to select a construction delivery strategy?

Scope of the Research

The scope of this research is to determine and define the parameters CER must evaluate in conducting a situation analysis for a FMS construction program, determine the rules-of-thumb CER uses to select a construction delivery strategy, and build a manual decision support system to aid CER in selecting a construction delivery strategy.

Middle East Focus

Over the past decade, most of the FMS programs requiring construction have been located in the Middle East (10:26). Ernest Graves and Steven Hidreth in their book 'U.S. Security Assistance: The Political Process' give an indication why a Middle East focus has been maintained.

> Concern for maintaining access to Persian Gulf oil had been a key element of U.S. policy

> since the Cold War began and since World War II. Security Assistance to nations that bordered on the Gulf, that were anti-Communist, and that were major oil suppliers to the industrial West was seen as a minimum investment in preserving the long-term security not only of the United States but of its major allies in Europe as well. (18:13)

Consequently, much of this research focuses on this area of the world since most of the literature and historical knowledge centers on policies and procedures adopted to meet the challenges encountered while implementing construction programs in the Middle East.

Construction Definitions

Construction industry terms have different meanings for different people. To standardize key terms, the following definitions are used:

Construction Program Manager: The Department of Defense (DOD) office responsible for monitoring the progress of the FMS construction program for a particular FMS program.

Design and Construction Agent (DCA): The government agency responsible for the overall management and implementation of a FMS construction program. The DCA can be the COE, NAVFAC, or CER. The DCA has the authority to select the construction delivery strategy.

Construction Manager (CM): The organization which accomplishes the definition, design and construction phases of a FMS construction program. The CM has the authority to

enter into contracts with design and construction contractors and provides design and construction management.

Construction Delivery Strategy: The CM chosen by the DCA for accomplishing the planning, design and construction phases of a FMS construction program.

Summary

A successful FMS construction program supports U.S. Air Force objectives in support of the national defense strategy. The successful completion of a construction program depends upon the construction delivery strategy which implements the planning, design, and construction of facilities. The construction delivery strategy selection process is complex and must consider information from multiple sources, thus complicating the selection process. The objective of this research is to build a decision support system to support the selection of a construction delivery strategy.

II. Background

Overview

This chapter traces the authority, processes, and responsibilities for the U.S. Security Assistance (SA) and Foreign Military Sales (FMS) programs. In addition, it summarizes past and present FMS construction programs with HQ Air Force Logistics Command (AFLC), Directorate of FMS Construction Engineers (CER) as construction program manager (CPM). It then highlights distinctions between the Military Construction Program (MILCON) and FMS construction, and discusses basic construction delivery strategy alternatives.

Security Assistance Authority and Process

This section describes the legal foundations to SA and FMS and describes the responsibilities and processes required to initiate a FMS program.

Foundations. The U.S. Security Assistance program has its foundation in U.S. public laws which provide SA program authorizations and financial appropriations. FMS, one component of the SA program, is a non-appropriated program through which eligible foreign governments purchase defense articles, services, and training from the United States Government (USG). The purchasing government pays all costs that may be associated with a sale regardless of whether the customer is paying cash or using money loaned to it through Congressional appropriations. The official government to

government agreement, referred to as a 'case', is documented on a DD Form 1513, Letter of Offer and Acceptance (LOA), which constitutes a contract between the U.S. Government and a foreign government.

Under FMS, military items may be provided from existing Department of Defense (DOD) stocks or from new procurement. On the basis of having a DD Form 1513 which has been accepted by the foreign government, the U.S. Government agency or military department assigned responsibility for the case is authorized to enter into a subsequent contractual arrangement with industry in order to provide the items requested (9:2-8).

Authorization Acts. The current U.S. SA program involves two laws; 1) the Foreign Assistance Act (FAA), and 2) the Arms Export Control Act (AECA).

The FAA, enacted on 4 September 1961, is the authorizing legislation for many SA appropriation programs, overseas SA program management, and a wide variety of other foreign assistance programs.

The AECA came into being under a different title, the Foreign Military Sales Act of 1968 (FMSA). The FMSA provided specific guidance and authorizations for FMS programs. The FMSA was amended by the International Security Assistance and Arms Export Control Act of 1976 (AECA), and is now known as the AECA.

Both the FAA and the AECA are amended by an annual or biennial security assistance authorization act, 'The

International Security and Development Cooperation Act of (year)', which defines SA appropriation levels (10:48-49).

Categories of Defense Articles. The Department of State maintains the United States Munitions List which categorizes defense articles authorized for FMS as identified in the International Traffic in Arms Regulations, Part 121, 'Arms, Ammunition and Implements of War' (11:700-2). Items on the munitions list which require special export controls because of their capacity for substantial utility in the conduct of military operations are identified as Significant Military Equipment (SME) (10:561). If the USG has incurred either a nonrecurring research and development cost of more than $50 million or has incurred a total production cost of more than $200 million for a SME, it is considered to be Major Defense Equipment (MDE) (11:700-2). Congressional notification requirements are based on the category to which a particular weapon system belongs.

Congressional Notification Requirements. Congress must be given notification of a weapon sale in certain instances.

> Section 36(b)(1) of the AECA requires that, in the case of any LOA to sell any defense articles ... for $50 million or more, ... or any MDE for $14 million or more, before such LOA is issued, a numbered certification must be submitted to the Congress indicating (a) the foreign country ... to which the defense article ... is to be offered for sale, (b) the dollar amount of the offer to sell and the number of defense articles to be offered, (c) a description of the defense article ... to be offered, and (d) the U.S. Armed Forces or other agency of the U.S. which is to make the offer to sell. (11:703-1)

> The AECA, Section 36(b)(1) states that the LOA shall not be issued ... if the Congress within 30 calendar days after receiving such certification, adopts a joint resolution stating that it objects to the proposed sale, unless the President states in his certification that an emergency exists which requires such sale in the national security interests of the U.S. (11:703-2)
>
> If Congress adopts a concurrent resolution objecting to a proposed sale, the Director, [Defense Security Assistance Agency] DSAA will promptly notify the applicable DOD component of that fact, seek the guidance of the President as to the course of action which should be taken, and advise the cognizant DOD component of the action to be taken. (11:703-8)

When a sale is approved by the Department of State and Congress has not objected, the FMS case can be implemented.

Preparation and Processing of FMS Cases. A foreign country desiring to purchase a weapon system must first request the sale through the Department of State. The Department of State then determines whether or not the sale can be approved, notifies Congress, if appropriate, and ultimately either accepts the offer or responds with a negative reply to the purchaser (11:700-5 through 700-7).

Types of Requests. FMS customers may submit requests for Price & Availability (P&A) data for preliminary planning or an LOA when plans to purchase defense articles are relatively firm.

P&A estimates reflect rough order of magnitude data, provided for planning purposes, showing projected availabilities and estimated costs for defense articles (11:700-1). When the Air Force is requested to provide P&A

data, the request is categorized as a Planning and Review (P&R) or P&A request. P&R data

> ...is not valid for programming budget requests or for preparing an LOA. P&R is computed on available information, often using standard US Air Force factors and formulas. Detailed information is usually not available. P&R data may be available within Air Staff offices or from recent similar P&R, P&A or LOA.
>
> The purpose of P&A data is to give the purchaser the best available estimate of costs and delivery times. ... When determining availability, all administrative, procurement or production and other leadtimes must be considered, including start-up time for closed production lines. (13:21)

When plans to purchase defense articles are relatively firm, the FMS customer may request a LOA. A LOA request itemizes the defense articles offered with associated cost estimates and, when accepted, becomes an official contract by the USG (11:700-8).

Acceptance Process. Eligible foreign countries desiring P&A data or a LOA must convey their desire to the USG in a Letter of Request (LOR) which specifies exactly what is desired. The Department of State has statutory responsibility for accepting and approving all requests for FMS to eligible countries. The Defense Security Assistance Agency (DSAA) and the Department of State initiate necessary coordination to determine if the request is to be approved, disapproved, or if further correspondence is required (11:700-5,700-6). When a determination is made that the USG cannot provide the requested sale, DSAA coordinates with the Department of State, who then conveys the negative reply to

the requestor (11:700-9). If approved, "signing of the LOA by the designated foreign official, together with applicable funding, constitutes the agreement of the foreign government ... and constitutes a contractual commitment between the U.S. and foreign government" (11:700-8). An approved LOA is effective until all articles defined in the LOA are delivered to the purchaser (11:700-8).

Responsibilities. Responsibilities for ensuring the SA program meets national policies and objectives begin with the President and filters through many organizations. The following excerpts from the Security Assistance Management Manual, published by the DSAA outline the major players and their roles.

> Within the Executive Branch, the National Security Council , the Office of Management and Budget, the Department of the Treasury, and others all have responsibilities related to security assistance. However, aside from the President, the principal legislated responsibilities fall to the Secretary of State and to the Department of Defense (DOD).
>
> The Secretary of State is responsible for continuous supervision and general direction of the program. This includes determining whether there will be a program for a particular country or activity and, if so, its size and scope. It also includes the determination of whether a particular sale will be made and, if so, when.
>
> The SECDEF [Secretary of Defense] is responsible primarily for establishing military requirements and for implementing programs effecting the transfer of defense articles ...
>
> The Congress authorizes and appropriates the funds for the USG financed portions of SA. Congress also has an oversight role with respect to the sale of defense articles ... to foreign countries ... .
>
> DSAA is the principal organizational element through which the SECDEF carries out his responsibilities for SA. It serves as the DOD

> focal point and clearinghouse for tracking arms transfers, budgetary, legislative, and other SA matters through the analysis, coordination, decision, and implementation processes. ... The agency is also responsible for the conduct of international logistics and sales negotiations with foreign countries, and the maintenance of liaison with and the provisions of assistance to U.S. industry in the export of military equipment ... All authorities conferred on the SECDEF by the FAA and the AECA, and all authorities under those acts delegated by the President to the SECDEF, are redelegated to the Director, DSAA.
>
> The Secretaries of the MILDEPs [Military Departments] advise the SECDEF on all SA matters that have an impact on their departments. They act for the SECDEF on SA matters only when the responsibility has been specifically delegated.
>
> MILDEPs have the performance of SA as an integral part of their overall defense mission. They procure and provide defense articles and services to meet approved SA requirements. They also are responsible for providing information necessary to ensure that proper SA planning can be accomplished. (11:300-1,2)

Security Assistance Organizations (SAOs) consist of all DOD elements located in a foreign country. "The purpose, under U.S. law, for establishing and assigning personnel to an SAO is for in-country management of international SA programs .. " (11:300-3). FMS construction personnel who are DOD employees fall under SAO authority.

Case Management. When an LOA is signed by both governments and the funds have been properly identified,

> The MILDEPs and Agencies will, according to Paragraph 70002H, DODD 7290.3-M, "assign a case manager to each active FMS case." The FMS case manager is to be designated by the Component responsible for implementing sales agreements (DD Forms 1513) ... . The case manager is defined as that individual who is designated to accomplish the task of integrating functional and inter- and intra- organizational efforts directed toward the successful performance of an FMS case.

> The case manager is the focal point for management activity on a case. The task of the case manager is to ensure the objectives of the assigned case are achieved while adhering to applicable laws and regulations.
>
> These objectives are threefold: (1) to accomplish the case (performance) on schedule, (2) to accomplish the case within the case value, and (3) to close the case as planned.
>
> The case manager acts as the focal point for case activities by coordinating and integrating organizational actions and resources assigned to Security Assistance functions. (11:704-1)

The case manager prepares a detailed plan to accomplish the objectives of a case called the 'case directive'.

Case Directive. The LOA provides the basic information, and authority for, a given FMS case; however, it does not provide the management plan to ensure program objectives are met. The case manager must prepare a case directive, also called a FMS Management Plan (FMSMP) in AFR 130-1, 'Security Assistance Management', to coordinate all aspects of a FMS program. This document becomes the governing document to implement a FMS case (9:8-11). The guiding principles are described as follows: "The FMSMP [case directive] serves as the primary FMS program management document in meeting milestones, assigning channels of communications and points of contact. The case manager is responsible for preparing, issuing, updating, and improving the FMSMP" (131:34). The Security Assistance Management Manual provides further case directive guidance.

> Tasks in the areas of acquisition, logistics and finance will be assigned to supporting activities using normal operating rules. The supporting activity which accepts the work assignment agrees to specific, measurable objectives and to detailed

task descriptions, specifications, milestones, and budgets for the work assignment. The supporting activity is then responsible for the work effort in terms of meeting its objective on time and within the available budget. (11:704-4)

Air Force Management of the SA Program. Several AF organizations have responsibility for managing their portion of the SA program. The Chief of Staff of the AF develops, implements, and manages SA as directed by the Office of the Secretary of Defense (OSD) (13:14). The Chief of Staff is supported by the following offices:

a. Directorate of International Programs (SAF/IARS) is the office of primary responsibility (OPR) for the central management, direction, guidance, and supervision of most of the US Air Force SA program. The directorate:

(1) Makes sure that SA programs interface with the other programs in conjunction with Air Force directives, and all OSD SA directives.

(2) Coordinates with DSAA and other agencies on the US Air Force political and military matters that may affect SA.

(3) Serves as the US Air Force point of contact for joint service actions that deal primarily with SA programs.

(4) Chairs US Air Force security assistance management reviews which involve FMS purchases.

b. Office of the Vice Chief of Staff (HQ USAF/CVAII) determines releasability under National Disclosure Policy. Approves visits by representatives of foreign governments and documentary disclosures to foreign governments involving classified and unclassified military information and training.

c. Directorate of Cost (SAF/ACC) is the OPR for implementing SA pricing policy and budgeting for ... all assigned FMS programs.

d. Directorate of Staff, Operations, Plans and Readiness (HQ USAF/XOO) helps to judge SA impact on US Air Force readiness ...

e. Other Secretary of the Air Force (SAF) and HQ US Air Force Offices:

(1) Provide SAF/IARS with the information and staff assistance needed to develop and implement SA programs.

(2) Help review and validate FMS programs and prepare planning and review (P&R) preparations, price and availability (P&A) estimates and releasibility determinations. They also help prepare, review, and present the LOAs.

(3) Help to procure and deliver articles and services for SA.

f. Directorate of Accounting and Finance (SAF/ACF) is responsible for developing US Air Force accounting and finance policies, procedures and systems for the security assistance program. (13:14)

All AF Major Commands (MAJCOMs) are responsible for various aspects of the SA program. Each MAJCOM establishes an international programs office to handle the SA program. The Assistant to the Commander for International Logistics (HQ AFLC/MI) manages Air Force Logistics Command's SA program as the Commander of the International Logistics Center (ILC). ILC prepares and issues LOAs for AFLC FMS programs (13:15-16). CER coordinates activities with the ILC to ensure information is received by the case manager (31;43).

FMS Programs Managed by CER

Since the inception of CER, the focus of their efforts has been in the Middle East. In particular, Saudi Arabia and Egypt have been recipients of SA programs involving weapon system sales and supporting facility construction programs. In all of the following cases, CER has been designated as the CPM. Also, in some cases, CER has been designated as design and construction agent (DCA) and, in other cases, the Corps of Engineers (COE) has been given DCA

authority. The following are FMS construction programs in which CER is, or has been, the FMS CPM.

Peace Hawk V (Saudi Arabia). Peace Hawk V was the construction portion of the Peace Hawk program which was a program to deliver F-5's to three Saudi Air Bases. Peace Hawk V included construction of aircraft maintenance facilities and base infrastructure valued at $310 million. Begun early in 1977 and completed in mid 1988, the DCA was the COE and the CM was Northrop, the weapon system supplier (14;23).

Peace Hawk VII (Saudi Arabia). Peace Hawk VII was a construction program added to the Peace Hawk program. The purpose of Peace Hawk VII was to enhance the security at five Saudi Air Bases and included perimeter roads, fences, lighting, and security gates. It was valued at $310 million with construction beginning in mid 1978 and completed at the end of 1989. The COE was the DCA and CM (15).

Peace Sun II (Saudi Arabia). Peace Sun II was the construction portion of the Peace Sun program which was a program to deliver F-15's to three Saudi Air Bases. Peace Sun II included construction of aircraft maintenance facilities and base infrastructure valued at $790 million. Begun in late 1978 and completed in mid 1990, the COE was the DCA and CM (15).

Peace Sentinel (Saudi Arabia). The Peace Sentinel program provided for the temporary beddown of E-3 Airborne Warning and Control System (AWACS) aircraft at Riyadh Air

Base. Existing facilities from an old airport were modified for the beddown until permanent facilities at a proposed new air base were completed. The project began in mid 1984, was completed in early 1988, and was valued at $50 million. CER was the DCA, and Boeing, the weapon supplier, was the CM (15).

Peace Shield (Saudi Arabia). By far the largest FMS program in Saudi Arabia, the Peace Shield program is ongoing and will deliver a ground-based air defense command, control, and communications system for the Royal Saudi Air Force. The primary scope of the construction program is to provide the following:

- Modify one underground Command Operations Center
- Construct five underground Sector Control Centers/Sector Operations Centers
- Construct 17 Long Range Radar Sites
- Construct 33 Communication Site Facilities
- Construct a Central Maintenance/Training Facility

The program began in early 1983 with a projected completion in early 1996. The construction value is currently at $1.5 billion with CER as the DCA and a Joint Venture between the private architectural engineering (AE) firms of CRS Sirrine and Metcalf & Eddy selected as CM (49).

Peace Vector II (Egypt). The Peace Vector II program provided for the beddown of 40 F-16s at Beni Suef Air Base. The construction program provided F-16 support facilities

through new construction. In addition, existing facilities were upgraded and a U.S. housing complex was constructed to house U.S. personnel supporting F-16 operations at the Air Base. The construction program was completed at a cost of $50 million. Design was accomplished through the COE and construction was accomplished through the Egyptian Air Force (EAF) using Egyptian Army labor. The program began in early 1982 and was completed in early 1988 (16:Sect D).

Peace Vector III (Egypt). The Peace Vector III program provided for the beddown of 40 F-16s at Abu Suwayr Air Base. The construction program provided for infrastructure work as well as construction of support facilities. The program began in mid 1986 and is scheduled to be complete in late 1991 at a cost of $195 million. Design was accomplished through the COE with the EAF performing construction using Egyptian Army labor (16:Sect D).

MILCON Versus FMS Construction

Most personnel dealing with construction in the Air Force are familiar with the MILCON program. There are three significant distinctions between the MILCON and FMS construction programs; how a design and construction agent (DCA) is designated, the process to conduct the programs, and change order authority.

Designation of a DCA. The first distinction is in the DCA determination process for each FMS construction program. The COE and Naval Facilities Engineering Command (NAVFAC)

have been designated as DCA and construction manager (CM) for the AF MILCON Program unless the SECDEF approves otherwise. Public Law 97-214, July 12, 1982: Military Construction Codification Act, Subchapter III, Section 2851. Supervision of Military Construction Projects states:

> Each contract entered into by the Unites States in connection with a military construction project...shall be carried out under the direction and supervision of the Secretary of the Army (acting through the Chief of Engineers), the Secretary of the Navy (acting through the Commander of Naval Facilities Engineering Command), or other such...agency as the Secretary of Defense approves to assure the most efficient, expeditious and cost effective completion of the project. (29:E-1.3)

The Secretary of Defense has allowed the AF to perform as the CM in the past few years for a limited number of MILCON projects; however, according to Mr J. B. Cole, Director of Construction and Environmental Services, HQ USAF, Office of the Civil Engineer, "The Air Force manages most of its design and construction through outside agencies, [the COE or NAVFAC]" (45). With few exceptions, public law requires that the DCA and CM responsibility for AF MILCON projects will be delegated to the COE or NAVFAC.

Designation of a DCA for the FMS construction program is case dependent and depends upon current policy handed down from various levels in the Legislative, Executive, OSD or HQ USAF branches of the USG (35;42).

<u>Process</u>. The second distinction focuses on the process required to conduct the MILCON and FMS construction

programs. The MILCON process is well defined with specific stages to identify, plan, program, budget, design and construct an individual facility project. The process includes specific congressional checkpoints to monitor the progress of the MILCON program and each proposed project is subjected to a detailed review each time the AF budget is prepared (6). A proposed construction project can remain in any stage along the way for an unspecified amount of time as it is continuously reviewed against overall requirements. Because of this, it may take several years for a single construction project to maneuver through each stage of the process from the time it is identified as a requirement until it is finally constructed.

FMS construction programs operate under the requirements of the LOA and case directives. Once a construction program is identified, individual facilities required to support the weapon system are identified, and a construction schedule is established to meet overall FMS program milestones. The entire construction program is funded up front and the facility program is managed as a whole rather than by individual projects. There are no specified stages to approve planning, design and construction activities by higher authorities. CER is given program management authority and is expected to meet overall program milestones without detailed oversight from Congress (25;44).

Change Order Authority. The third distinction is the change order authority levels in the MILCON versus FMS construction programs. In the MILCON program, rules for cost and scope changes are well defined. Designated authority levels from Congress are delegated to HQ USAF and to MAJCOMs. Project costs cannot exceed congressionally established thresholds without approval from Congress. Cost changes within the thresholds can be approved by HQ USAF or MAJCOMs. In addition, extensive justification must be prepared to obtain approval to change any MILCON project (29).

Change order authority for FMS construction programs resides with the purchasing country. The purchasing country determines changes desired in the construction program with two broadly defined requirements. The first requirement is that the change must not substantially modify the original agreements identified by the LOA for the FMS program (11:804-2;31). The second requirement is that if funds are not available within the funding authorizations of the LOA, and the purchaser insists the change is necessary, the purchaser must provide additional funding to cover the cost of the change (31).

Construction Delivery Strategy Alternatives

There are four construction delivery strategies available to CER to perform the role of construction manager (CM); U.S. Government agencies, private AE firms, the weapon

supplier, and the purchasing country. This section describes each alternative and the methods used to obtain CM services.

U.S. Government Agencies. Two USG agencies are available to manage a FMS construction program, the COE and the NAVFAC. The COE is the Army organization responsible for major design and construction efforts for the Army, Air Force, and other federal agencies. The NAVFAC provides the same service for the Navy and the AF (17:179,180). Both agencies provide a full range of services including planning, programming, design, construction, turnover, and warranty. In addition, both agencies provide contract supervision and administration services. Worldwide DCA authority has been divided between the COE and NAVFAC as indicated in Appendix A (29:E-1.9).

Typically, when construction services are required, a request letter is sent to the agency headquarters stating the requirement. The headquarters, upon approval of the request, assigns a district to work with the requestor, and a Memorandum Of Understanding outlining the roles and responsibilities of each party is established. Government agencies typically charge a percentage-of-cost fee for MILCON programs; however, a negotiated fee structure must be established for FMS construction programs (23;26).

Private AE Firm. A private AE firm provides the same CM service as government agencies with the exception of contract administration. Procuring a private firm is

controlled by Public Law 92-582; 86 STAT. 1278 'Public Buildings -- Selection of Architects and Engineers'. This law, frequently referred to as the Brooks Act, defines AE services as "professional services of an architectural or engineering nature performed by contract that are associated with research, planning, development, design, construction, alteration, or repair of real property" (2:A-4). The law goes on to say, "The Congress hereby declares it to be the policy of the Federal Government to publicly announce all requirements for architectural and engineering services, and to negotiate contracts for architectural and engineering services on the basis of demonstrated competence and qualification for the type of professional services required and at fair and reasonable prices" (2:A-5). Acquiring a private AE firm under the Brooks Act typically requires 8-12 months (22:30).

Weapon Supplier. Some weapon manufacturers can provide CM services. In the Peace Sun and Peace Sentinel programs, the weapon supplier performed the role of CM. There are two situations where a weapon supplier may be designated as the CM. The first is when this method is directed by the LOA, and the second is when the weapon supplier bids and wins through the competitive selection process for private AE firms. In either case, they would be contractually managed the same as an AE firm (20).

Purchasing Country. Countries with the capability to perform full or partial CM services will either ask to

perform this role or CER will ask them to perform this role after a country assessment determines that internal capabilities exist (40). If the purchasing country performs the CM role, their own national funds must be used instead of FMS funds. In this case, CER is the construction program manager and acts as an advisor to the purchasing country (32). If the purchasing country does not perform the CM role, then one of the other methods, government agencies, private AE firm, or weapon supplier, must be used.

Summary

Legislative and Executive branches of the U.S. Government are responsible for ensuring SA and FMS programs assist in meeting national defense objectives. This chapter outlines these responsibilities and defines the general process to initiate and manage a FMS case. Additionally, it reviews past and present FMS construction programs, discusses fundamental differences between MILCON and FMS construction, and identifies alternative construction delivery strategies.

III. Methodology

Overview

This chapter discusses the methodology used to build a decision support system (DSS) to assist the Directorate of FMS Construction Engineers (CER) in selecting a construction delivery strategy. The concept of a decision support system (DSS) in the context of a computer expert system is discussed, followed by the methodology used to build a non-computerized DSS for CER.

Decision Support System Definition

A decision support system (DSS) is a tool, usually computer-based, that possesses some decision-making or decision-aiding capability (7:693). A DSS presents information to a decision maker in a manner which simplifies the decision making process (7:700-701). The difficulty in developing a DSS is determining the information required to make a particular decision and then understanding how the information is processed by the decision maker to finally reach a decision (7:703-704).

The field of artificial intelligence has created a tool, called expert systems, which has formalized gathering and manipulating data required in decision making. According to Donald A. Waterman in his book, 'A Guide to Expert Systems',

> Expert Systems are sophisticated computer programs that manipulate knowledge to solve problems efficiently and effectively in a narrow problem area. Like real human experts, these systems use symbolic logic and heuristics - rules of thumb - to find solutions. ....by linking the power of computers to the richness of human experience, expert systems enhance the value of expert knowledge by making it readily and widely accessible. (46:xviii)

In essence, an expert system uses information gathered in developing a DSS, formulates it into a computer model and produces solutions using information and expert heuristics.

Using the Expert System Process to Build a DSS

The development of expert systems has created a systematic approach to collecting and formalizing knowledge into a format which can be used in a computer model. There are five stages in the development of an expert system. They are: 1) Identify and characterize the important aspects of the problem; 2) Conceptualize and begin explicit definition of key concepts and relationships among the important aspects; 3) Formalize the key concepts and information flow into a more formal mapping representation; 4) Implement formalized knowledge into a framework that fits a particular computer tool and develop a prototype system; and 5) Test the accuracy of the prototype system until it represents the actual problem (21:140-148).

In order to build an expert system, the knowledge required to make a decision must be determined from an expert or experts. This knowledge, known as the 'knowledge base', can then be configured into an expert system. Time

constraints limit this research to developing a knowledge base and then building a manual DSS from the knowledge base. A follow on project is required to utilize a formal computer tool in building a complete expert system. The reason for concentrating on developing the knowledge base given the time constraints revolves around the amount of time required to gather the information required to build an expert system.

> Knowledge in an expert system may originate from many sources, such as textbooks, reports, databases, case studies, empirical data, and personal experience. However, the dominant source of knowledge in today's expert systems is the domain expert. A knowledge engineer usually obtains this knowledge through direct interaction with the expert.
>
> This interaction consists of a prolonged series of intense, systematic interviews, usually extending over a period of many months. (46:152)

Because of the fifteen month time frame of the Graduate Engineering Management Program, it was deemed prudent to limit the scope of this project to building a manual DSS versus a fully computerized expert system.

DSS Building Process

This section describes the type of knowledge required and the two stages used to build a construction delivery strategy DSS; knowledge acquisition and building the DSS.

There are two types of knowledge, public and private.

> Public knowledge includes the published definitions, facts, and theories of which textbooks and references in the domain of study are typically composed. But expertise usually involves more than just this public knowledge. Human experts generally possess private knowledge

> that has not found its way into the published literature. This private knowledge consists largely of rules of thumb that have come to be called 'heuristics'. Heuristics enable the human expert to make educated guesses when necessary, to recognize promising approaches to problems, and to deal effectively with errorful or incomplete data. (21:4)

This research builds a DSS in two stages. The first stage, knowledge acquisition, primarily uses private knowledge and develops the knowledge base by combining the first three steps of expert system development; 1) identify key concepts, 2) conceptualize relationships, and 3) formalize the information into a framework. The knowledge acquisition stage is presented in Chapter IV. The second stage, building the DSS, develops a manual DSS using the information from the knowledge acquisition stage. Stage two represents step 4, implement framework into a prototype, of developing an expert system and is presented in Chapter V. The actual steps of formalizing information into a computer prototype and testing the prototype, which are part of steps 4 and 5, are not included in this research.

Knowledge Acquisition. Knowledge acquisition is the first stage in the DSS development process. In this stage, information to support parameters which the Directorate of FMS Construction Engineers (CER) must use to determine an initial situation analysis are identified, defined, and given extreme values which can be placed at opposite ends of a continuum. This aspect of the knowledge acquisition stage is called parameter development. Then, strategy heuristics

are determined which are rules-of-thumb CER uses to determine the best construction delivery strategy.

Parameter Development. An extensive research effort into public sources revealed almost no published sources of information concerning FMS construction. Several inquiries into the Defense Technical Information Center (DTIC) data base at the Air Force Institute of Technology (AFIT) library were conducted. The DTIC database includes an extensive listing of published works concerning military topics. In addition to searching the AFIT library, a search through the Wright State University Library, the Dayton University Library, and the Wright Laboratory Technical Library and the Defense Institute of Security Assistance Management Library on Wright-Patterson AFB was also conducted. A determination was made that public knowledge of FMS construction was not available to support the research.

Because of the lack of public knowledge concerning FMS construction, the primary source of information was deemed to be private and was gathered through extensive meetings with CER management and FMS construction experts from private industry. These meetings revealed that program reports and private architectural engineering (AE) firm literature was available to support the effort. An extensive interviewing process with CER staff and various AE authorities outside CER assisted in defining and developing the parameters. In addition to sources in CER and AE firm

personnel, the Air Force Institute of Technology, School of Civil Engineering and Services conducts a Project Management Course which provided excellent sources of information.

A rough draft of parameter definitions was completed and a copy was distributed to CER staff and private architectural engineering contractor employees working with CER. Any comments received were discussed and, if appropriate, incorporated into the document. This step was necessary to ensure that information gathered to support the parameter development was adequate and complete.

After parameter information was gathered, two extreme values were assigned to each parameter which allowed development of a Parameter Assessment Guide which places the two extreme values at opposite ends of a continuum. Personnel in CER and private industry experts reviewed the entire package again to ensure the accuracy and thoroughness of the parameter content. Any comments received were discussed personally and if appropriate, incorporated into the data.

Strategy Heuristics. Upon completion of parameter development, a combined package of defined parameters and the Parameter Assessment Guide were distributed to CER personnel with instructions to indicate if any specific construction delivery strategy is preferred as a parameter progressed to either end of the continuum. Additionally, personal interviews with CER management were conducted to discover heuristics used to select a particular delivery

strategy. These two sources of information were combined to formulate strategy heuristics.

After parameter development and determination of strategy heuristics, the DSS was developed.

Building the Decision Support System. The second stage of DSS development builds the DSS to assist in the selection of construction delivery strategies for FMS construction programs managed by CER. With the information gathered from the strategy heuristic development, the parameters were prioritized and certain continuums rearranged to develop a Strategy Decision Guide. Chapter V discusses the development of the resulting Strategy Decision Guide.

Summary

This chapter discusses how development stages of an expert system can be used to build a DSS. This methodology is then discussed in developing a DSS to assist CER in selecting a construction delivery strategy. The first stage, knowledge acquisition, includes parameter development and strategy heuristics. The second stage, building the DSS, uses the information from the knowledge acquisition stage to build the DSS.

IV. Decision Support System - Knowledge Acquisition

Overview

This chapter documents information gathered during the knowledge acquisition stage of this research project. Parameters which the Directorate of FMS Construction Engineers (CER) use to conduct a situation analysis of initial conditions are identified, defined and assigned extreme measurement values. A Parameter Assessment Guide is then developed to assist CER in assigning values to each parameter during the situation analysis. Strategy heuristics are then identified which CER personnel use to determine the best construction delivery strategy given the initial conditions.

Parameter Development

When CER is designated as design and construction agent for a FMS construction program, a situation analysis must be conducted to determine initial conditions which can guide CER in selecting a construction delivery strategy. There are seven parameters CER must evaluate at the start of any FMS construction program to determine the initial conditions. Based upon the research, they are summarized as follows:

1. Customer Assessment - Determine customer requirements and existing conditions within the purchasing country.

2. Weapon System Assessment - Determine the weapon system's development stage and complexity of design effort required to support weapon system facility requirements.

3. Political Environment - Determine how much flexibility CER has in choosing a construction delivery strategy.

4. Program Schedule - Determine the amount of time available for the construction program to meet weapon system delivery schedules.

5. Staffing - Determine personnel requirements for construction program management.

6. Contract Options - Determine the contracting strategy to perform planning, design and construction phases of the program.

7. Responsiveness - Determine the degree of responsiveness required for initial planning requirements and program modifications.

The following sections provide detailed descriptions of the seven parameters.

1. Customer Assessment. The first task CER needs to accomplish when designated as design and construction agent for a FMS construction program is to assess the wants, needs, and capabilities of the purchasing country. In order to translate customer requirements into specific facility requirements, CER must conduct a detailed study of purchaser requirements and existing internal conditions which will impact design and construction activities. If this study is

not conducted properly, the purchaser will end up with something different than what was intended (40).

A. Requirements. Knowledge of desired involvement levels of the purchasing country, air base planning concepts, and quality expectations determine customer requirements.

i. Host Country Involvement. The first element that needs to be evaluated is the degree of management involvement the country has requested (3). In addition to program management, involvement of foreign contractors in design and construction activities may be requested. CER must compare the requested level of involvement against the capabilities of the purchaser, give a feasibility judgement to the purchaser, and then plan for the level of involvement requested within the foreign country's capabilities (22).

In order to provide an assessment, CER must evaluate construction management structures and processes that exist within the country. In general, the more economically developed a country is, the more established the construction industry will be. An established construction industry generally has defined procedures and methods to accomplish construction within the country. The more these procedures and methods are defined, the easier it is to work with the country's management (3).

An example of host country involvement was when the Egyptian government wanted to perform construction using

Egyptian Army personnel and Egyptian contractors for the beddown of two F-16 squadrons (Peace Vector II and III). The USAF and the Egyptian Air Force (EAF) provided the design documents and the COE provided construction management expertise and construction materials consisting primarily of mechanical and electrical components. Egyptian construction methodologies are generally less developed than the U.S. construction industry. Because of this, an organization called the Joint Management Engineering Team consisting of USAF, COE, EAF, and Egyptian Army personnel was developed to provide a mechanism for the U.S. to advise Egyptian managers. The effect of the arrangement was to slow down the design and construction process, but the objective of the EAF was to gain the knowledge of U.S. construction standards and principles, which was accomplished (5;28).

A country's involvement level can range from no involvement to complete involvement through every stage of the program (33).

ii. Air Base Planning Concepts. Delivering an AF weapon system requires the use of air base planning concepts to assist in planning and designing facilities. The principles as stated in draft AF Manual 3-C, 'Combat Air Base Performance Planning' are:

> REDUNDANCY - provision of immediate alternatives or backup for war-critical facilities and resources

RESILIENCY - planning for flexible and adaptable facilities and systems that can be used for multiple purposes during the stress of war

RELIABILITY AND MAINTAINABILITY - operational and functional design of facilities and systems to make them dependable

INTEROPERABILITY - standardized facilities, systems and procedures that can be interchanged quickly

ACCESSIBILITY - functional linkage of facilities that enables rapid interaction among related activities

SUSTAINABILITY - ability to maintain operations and generate sorties for the duration of the conflict

WARNING, ASSESSMENT, AND CONTROL - real-time situation assessment and communication of important combat information

PLAN FOR PEOPLE - recognition of human factors in facility layout, design, and operations

PROTECTION OF RESOURCES - physical protection of facilities, their contents, and utilities as well as evacuation and base denial

COMBAT SITING - selection of the place that ensures optimum force projection, defensive effectiveness, access to critical resources, and resupply routes (12:4)

During the planning phase, the planning staff can use these concepts to balance base location, facilities, and utilities siting and determine how the base will operate under wartime conditions. Planning requires a team approach from operations, security, logistics, engineering, and other personnel with the knowledge and expertise to contribute to overall planning concepts (12:3,4). Draft AF Manual 3-C provides further details required to assess air base planning concepts as does AF Manual 3-2 'Civil Engineering

Combat Support Doctrine'. The concepts presented in these manuals can guide CER in developing facility plans for foreign air bases.

Using these concepts as a baseline, CER can then assess the purchasers requirements for air base planning. As a foreign country's concept becomes less advanced, less sophisticated levels of redundancy, resiliency, reliability, maintainability, etc., are required to support a weapon system. Depending on the program, an education process may need to be conducted to assist the foreign country in understanding air base planning concepts (33).

A general officer from a foreign country, for example, considered an avionics shop hardened even though every one of the supporting systems to the shop were located in a metal shack beside it. Destroying the shed would have rendered the entire shop inoperable (5).

A foreign country's air base planning concepts can range from simple to advanced based on a particular weapon system (33).

iii. Quality Expectations. Facility quality level expectations of the purchasing country will determine the level of detail required to design and construct facilities. If the country is willing to accept a quality level that is less expensive versus a first class quality level, the method of accomplishment can differ (5).

In the Saudi Arabian Peace Shield program, the Saudi government wants, and can afford to pay for, facilities that

include state-of-the-art mechanical/electrical systems, security systems and advanced hardening capabilities. In addition, materials and workmanship are expected to be in strict compliance with construction contract specifications. In other foreign countries, quality expectations may be much lower than U.S. standards. These type of quality expectations allow for less stringent management practices. In these instances, CER can perform an educational role to the foreign country to help improve quality expectations.

A country's quality expectations can range from low to high (33).

B. Condition Survey. The three previous elements, host country involvement, air base planning concepts, and quality expectations, deal with the purchasing country's requirements. A detailed look at existing conditions within the country is also required. A condition survey considers existing site conditions, skill availability, material availability, infrastructure, weather and topography, permitting, and local customs and laws.

i. Existing Site Conditions. Existing site conditions can be determined by conducting site visits to potential construction sites. Important considerations are access to the construction site, the impact of adjacent facilities to the construction effort, and the impact to current operations if it is a renovation project.

Existing site conditions can range from a bare site at a remote location to a developed site adjacent to other

facilities in a metropolitan type area. Additionally, if the site is in a developed area, it can be an uncongested site with easy access for construction activities or it can be a congested site where construction activities are difficult to perform (4;34).

ii. Skill Availability. Construction labor skills available within a country can be used for construction; however, the skills available depend on the economic development of the country and the degree of the construction program sophistication. As labor availability in a country decreases and level of construction program sophistication increases, the need to import construction labor increases. Importing labor can drive up the cost of the construction program and requires considering other issues such as immigration and labor laws. Coordinating these issues with government agencies inside the purchasing country can add coordination requirements which add cost and time to the construction program. The process of getting the skill base required for the program may be costly in terms of dollars and time (3).

In Saudi Arabia, where construction sophistication was relatively high, almost all skills had to be imported from other countries. Foreign construction companies from Korea, Taiwan, and Belgium provided most of the construction capabilities.

Skill availabilities can range from none available in the country to all skill levels being available (33).

iii. Material Availability. Material availability within a country to support a FMS construction program is driven by the country's capabilities and the weapon system. Typically, the more advanced a country is economically, the more materials will be available in that country. In addition, the more sophisticated the weapon system is, a greater need for more sophisticated building materials usually results. The less materials available and the more complex the facility, the more materials that have to be imported. Imported materials drive up construction costs and require more interaction with government import/export agencies which adds time to the delivery schedule. Concrete and common construction materials can usually be found in the country or production capability can be established. Electronic components, heating, ventilation, air conditioning, and security system specialties may have to be imported (3).

Early on in the Peace Shield construction program, an extensive program to identify, order, and deliver unique construction materials had to be developed to ensure materials and equipment were available at a specific location when the construction contractor required them.

Material availability values can range from common materials being available to all construction materials required being available in the country (33).

iv. Infrastructure. The condition of a country's infrastructure can be determined by evaluating the

national highway and utility systems. The extent and condition of the national highway system will determine how materials will be shipped to specific construction sites. The existing utility infrastructure determines the degree of utility support that will be available during the construction effort and, upon completion, the support available to operate facilities (3). Critical utilities for a construction program are water, electricity, and communications (41).

Several million dollars had to be spent to provide temporary utility support to a $52 million underground command post for the Saudi Arabian Peace Shield program because no utilities were available. The Saudi Arabian national program to provide these utilities was behind schedule and alternative means had to be developed. Additionally, most of the seventeen remote radar sites had no utility or road systems available for use. Utility support and roads had to be provided, which added expensive construction modifications to the construction program.

Infrastructure values can range from undeveloped to developed (33).

v. Weather and Topography. Weather conditions and topography of the country need to be investigated to determine the length of the construction season and the type of existing landscape. A shorter season will either extend the construction schedule by requiring construction to be spread over more seasons or require more

innovative methods to accomplish more construction during the season. Topography affects how construction is accomplished. Mountainous regions require different methods of construction than does the desert, or the high water table regions of a coastal area (3).

In the desert conditions of Saudi Arabia during the Peace Shield program, where temperatures range from 110-130 degrees Fahrenheit, an example of a unique construction technique was adding ice to the concrete mix while in the truck to keep the concrete cool.

Weather and topography values can range from moderate to extreme (33).

vi. Permitting. Obtaining the necessary approvals to begin a construction project in the U.S. "...may include the user, the client's management, environmental groups, civic associations, zoning boards or historic preservations societies" (22:8). In foreign countries, the coordination process may also include regional leaders, local religious leaders and an assortment of various groups or individuals who have claim over some aspect of a piece of land (4).

In the Peace Shield program, the Royal Saudi Air Force was responsible for acquiring land for remote radar sites. More than once, construction personnel were denied access to a construction site until the local leader was assured the boundaries were clearly delineated.

Permitting values range from minimal to extensive coordination requirements (33).

vii. Local Customs and Laws. Any foreign country will have its own peculiar customs, history and laws which will affect construction productivity when compared to U.S. customs and laws. Holidays, special events, labor laws, and religious customs are some of the considerations that need to be determined (4). Typically, the more a country's customs and values differ from U.S. conventions, the greater the impact to the construction program. Since much of the work accomplished by CER in the past has been in the Middle East, a working knowledge of Muslim customs has been acquired and adhered to by CER construction program managers.

One requirement, for example, is that if a Mosque (prayer room) is being built into a facility, a General Priest, or Holy Man, having jurisdiction in that area, must perform a ceremony declaring the Mosque to be oriented correctly toward Mecca (27). To be declared an official Mosque, a local religious leader must lead the first prayer in the Mosque (19). These religious customs have significant design and construction implications since the correct orientation must be designed into the facility and construction of the minimum requirements must be completed as soon as possible to allow the General Priest to certify the correct orientation. If delayed, the whole room may need

to be reconstructed, which could significantly affect surrounding construction activities.

However, delaying final completion of the Mosque is equally as important because, once commissioned as an official Mosque, a non-muslim may not enter the room. If construction workers are predominantly non-muslim, as was the case in Saudi Arabia, completing the work could prove difficult after the Mosque is commissioned.

Values for local customs and laws can range from completely unfamiliar to familiar (33).

2. Weapon System. The weapon system being sold to a foreign customer must be assessed in terms of development stage and design complexity. The less developed the weapon system and the greater the design complexity, the greater the impact to the construction program

A. Development Stage. Three elements are important when assessing the development stage of a weapon system; availability of facility design criteria (FDC), who is managing the FMS program, and the degree FDC development overlaps with the facility design phase.

The first element to determine is whether or not there is published FDC for the weapon system. If there is, design can begin immediately on the facilities because facility requirements are known (43). FDC are typically fully developed for proven weapon systems that have been deployed with full operational capability. For instance, delivering a squadron of F-15 or F-16 aircraft is relatively simple

because facility requirements are clearly defined for the designer in the FDC, making the job of designing facilities to meet the requirements easier (24). When a weapon system is bought with only a concept of the weapon system on paper, the FDC are not available and facility design activities must wait until at least partial FDC are developed (43).

After FDC status is determined, assessing the management structure of the FMS program is important. If the weapon system is relatively undeveloped, the FMS case manager is often an expert in developing the weapon system. The program focus may tend to be on 'developing', rather than 'delivering' the weapon system. In this case, extra effort is required to coordinate facility concerns accurately and quickly to ensure all facility issues are addressed. If a mature system is being sold, the case manager typically will be familiar with delivery aspects of the system. In this situation, facility concerns and issues are more easily addressed within the FMS program structure (43).

Finally, in determining the development stage of a weapon system, CER needs to determine whether FMS program milestones will force FDC development to overlap with facility design. This overlap can be determined by developing a design and construction schedule based on FMS program milestones, then overlaying the facility schedule with the anticipated FDC development schedule. As would be expected, the less overlap with facility design phases, the

better off the construction program will be. Developed FDC prior to facility design allows more emphasis on designing the facilities properly from the start with known requirements.

FDC development that overlapped with facility design was the situation in the Peace Shield program where no definite FDC initially existed. The decision was made to begin the design phase with only part of the FDC developed and procurement of construction contractors began with incomplete designs. FDC updates were sent directly to construction sites to alert construction contractors of an impending design change and to give some indication of the magnitude of the change. Some sites ceased work on specific areas and concentrated on other areas until the design change was received (25).

CER can determine the development stage of a weapon system by evaluating the FDC development stage, FMS program management, and degree of FDC development overlapping facility design.

Weapon system development values range from conceptual to proven (33).

<u>B. Design Complexity</u>. Along with assessing the weapon system development stage, the weapon system complexity must be evaluated. Four elements, based on FDC requirements and a threat assessment, can increase the facility design complexity; existing site conditions,

hardening requirements, site deception versus camouflage concepts, and the contamination threat.

Before any design can begin, a site survey must be conducted to determine existing site conditions. This was discussed under customer assessment above (30;43).

Hardening is typically a military unique requirement which adds to design complexity. The more hardening requirements, the greater the design complexity (30). There are two aspects to hardening that need to be addressed; shock handling capabilities and redundancy requirements of the system.

Shock handling capabilities are two-fold, structural shock absorption and vibration isolation/shock attenuation. The first deals with the ability to absorb shock waves and is based on the bomb threats that are established. The second capability deals with the ability to transmit the shock waves through the facility so they are dampened without destroying the facility and to isolate critical equipment from the structure so it is not damaged (43).

Redundancy requirements deal with utility system capabilities to maintain operations during a contingency. For instance, the power requirement for a Peace Shield radar site was to use commercial power with four generators available for use in a contingency; two for backup power, one on standby status, and one which could be down for maintenance. Major design effort was required to include mechanical and electrical capabilities for this power

requirement. In addition to power requirements, redundancy considerations must be considered for mechanical systems, waste disposal systems, and any other system required to sustain life support or operational capability (30).

Site deception versus camouflage concepts are determined by the perceived threat. Site deception is attempting to make the enemy believe the target is something other than what it is, whereas camouflage is trying to make the enemy believe there is nothing of value at that location (30). Obviously, the greater the degree of either of these factors required in the project, the greater the degree of difficulty in the design process.

For example, in the Peace Shield program, Long Range Radar facilities were constructed with rock berms surrounding and covering the facility. The design effort included structural capabilities to handle the additional ceiling loads and many facilities had to be designed to be partially buried.

The last element which can increase design complexity is the contamination response capabilities which must be designed into facilities. Three contamination threats are possible; chemical, biological, and nuclear. The inclusion of any of these threats in the design process will require unique mechanical and structural considerations in order to keep the contamination out of the facility (30).

Critical facilities in the Peace Shield program had to be designed with blast doors and special mechanical blast

protection panels. In addition, all cable runs had to be placed within interior walls instead of exterior walls to protect from possible contamination (30).

Design complexity elements are driven by FDC requirements and the threat assessment for the weapon system. The concepts must be developed before the design effort begins to ensure all elements are accounted for in the design phase (30).

Design complexity values can range from standard to complex requirements (33).

3. Political Environment. With limited exceptions, the AF is required by law to use the Corp of Engineers (COE) or the Naval Facilities Engineering Command (NAVFAC) as the design and construction agent for the Military Construction (MILCON) program. As was noted in Chapter II, worldwide government agency responsibility for MILCON has been divided between the COE and NAVFAC. HQ USAF, Office of the Civil Engineer (HQ USAF/CE) policy is to use a government agent as construction manager for all AF managed construction projects with limited exceptions. This policy can, and should be, challenged when a more appropriate construction management method is available (5).

The existing political environment determines the degree to which this policy can be challenged. As the Department of Defense budget becomes leaner in the 1990's and funding for facility construction decreases, the COE and NAVFAC may want to maintain their worldwide organizational

infrastructures. If the Congress or the Executive branch in the U.S. Government are of this same opinion, the policy may be difficult to challenge. CER must gather information from HQ USAF and DOD organizations to determine the political environment, then work with HQ USAF/CE to determine if a strategy other than the COE or NAVFAC should be pursued. (5;31;40)

If the political environment assessment determines the policy to be firm, CER must use the COE or NAVFAC as the construction manager; however, an adequate situation analysis must still be conducted to determine the initial conditions existing in the program. If the political environment does allow CER to choose a construction delivery strategy, a detailed situation analysis must be conducted to aid CER in selecting the best construction manager. In either case, a situation analysis must be conducted.

The political environment is an important aspect of a situation analysis because it determines CER's ability to challenge the AF policy to use the COE or NAVFAC as the construction delivery strategy. If CER determines that conditions exist which warrant another strategy and the political environment is reluctant to allow other delivery strategies, CER must determine how hard the policy should be challenged. Assessing the political environment does not actually help CER select any particular construction delivery strategy over any other strategy and is not considered as a factor in choosing the best construction

delivery strategy. The political environment assessment is specifically needed to determine the degree to which CER should challenge the AF policy of assigning the COE or NAVFAC as the CM.

Political environment values range from no choice to CER being allowed to choose (33). The degree of being able to choose a construction delivery strategy determines the degree to which AF policy should be challenged (5;31).

4. Program Schedule. Every FMS program case manager prepares a case directive with specific milestones for various aspects of the program. In general, FMS program schedules drive the facility delivery schedule. The more condensed the program delivery schedule, the more the construction program must move from using traditional construction approaches to assessing alternative means of accomplishing the work in an expedited manner (24;47).

This situation is the case in the Peace Shield program. The entire FMS program is valued at just under $4 billion; the facility construction program is currently valued at $1.5 billion. System delivery schedules forced the construction program to expedite design and construction efforts while the system was still in the research and development stage. The FDC was only partially developed and, as a result, numerous design changes caused many construction changes which seriously increased the cost of the construction program.

Program schedule values range from condensed schedules to having ample time to complete design and construction activities (33).

5. Staffing. Any FMS construction program with CER as the designated design and construction agent will require AF and CM staff in the continental U.S. (CONUS) and in the purchasing country. Two capabilities must be present; the capability to plan and organize a FMS construction program and the capability to implement the construction program. The number and location of staff required for each capability is determined by the size of the construction program and the selected construction delivery strategy for each FMS construction program. If no staff are currently located within the purchasing country, a build-up team may be required to establish the capability for operations within the country (31).

Planning. CER is the planning function for designated FMS construction projects. In this role, CER is responsible for determining FMS construction program requirements in terms of schedules, budgets, and manpower requirements for CER and potential CMs. Planning information is provided to the Air Force Logistics Command's security assistance manager, the International Logistics Center (ILC), HQ USAF/CE, and various other organizations supporting a particular FMS program. Each FMS construction program may require CER to add staff or use existing staff (31).

Implementation. Every FMS construction program will require two implementation teams; one to implement the design effort and one to implement the construction effort. A third team, contract administration, may be required depending on the strategy selected (31).

Most design efforts are accomplished by the CM in the CONUS and are monitored by CER. Consequently, CER staff is made up of engineering disciplines able to communicate design requirements to the CM, then monitor the progress and quality of the design effort. The size of CER's staff required to monitor CM design will be about the same regardless of the construction delivery strategy chosen because the COE, NAVFAC, and private firms provide the same capability to translate design requirements into construction documents. CER must also determine the capabilities of potential Cms to provide adequate design staff in a timely manner for a particular construction program. The size of the design team is determined by the size of the project and the timeliness requirements are driven by the program schedule (31).

The construction monitoring team will always be located within the country where construction is being accomplished. CER personnel need to perform quality control, change order control, and cost management functions. To perform these tasks, various engineering disciplines are required to be able to communicate engineering issues and concerns to various customers such as

CM personnel, managers from the host country, various types of contractors, and security assistance organizations in the foreign country. Additionally, they must be able to relate information to the planning function in the CONUS (3;31).

In addition to CER's capability to monitor the construction, CER must assess the capabilities of potential Cms to mobilize staff in the country. A potential CM with staff present in the country will be able to provide construction capability faster than a potential CM without staff available in the country (3;31).

A third team may be required depending on the strategy selected. Under U.S. Federal Acquisition Regulation (FAR) requirements, authorization to enter into and modify any contract between the U.S. Government and a private contractor is given to an authorized government official called the contracting officer (CO). The CO's function, referred to as contract administration, is responsible for ensuring contracts are entered into and implemented in accordance with applicable U.S. laws (2).

For construction projects, construction engineers are usually assigned to perform as technical representatives to the CO to assist in making contract administration decisions. Contract administration and technical representative capabilities are a component of the COE and NAVFAC organization, a private firm does not have this capability. If a private firm is chosen as construction

manager, CER must provide technical representatives which increases the amount of staff required in the country (31).

In the Peace Shield program, where a private firm is the CM, the CO is located at the San Antonio Air Logistics Center in Texas. The CO is assisted by administrative COs in Saudi Arabia who are, in turn, assisted by technical representatives located at various construction sites throughout Saudi Arabia.

Build-up. There are three possible situations CER will face when determining the in-country staffing requirements for a construction implementation team; there can be existing staff adequate to take on the proposed project, existing staff may need to be supplemented, or there may be no staff present. If no staff are present, a team may need to be sent into the country to establish the capability to implement construction efforts. This team will need to address housing, transportation, office space, etc. for the construction implementation function. If staff are present within the country, they should be able to provide the support needed for any additional staff required (31;48).

Staffing requirements revolve around planning and implementation functions which every FMS construction program requires. CER must ensure that adequate staff are available to accomplish each capability.

Staffing values range from no staff to existing adequate (33).

6. <u>Contracting Plan</u>. Every construction program involves three distinct phases; project definition, design, and construction. Chuck Thomsen, President of 3D/International, Inc., states, "The phases can be overlapped, telescoped, combined, subdivided, and regrouped, but they can't be eliminated" (38:3). The decision which determines the degree of 'overlapping, telescoping, etc.' is what determines the contracting plan.

CER must make decisions regarding the type of contracting plan it wants a CM to manage in delivering a facility project. Mr. Thomsen, in his handout to the Project Management Course at the Air Force Institute of Technology, provides an excellent summary of construction contracting plan concepts This handout has been included as Appendix B. In his handout, Mr Thomsen indicates four key decisions which are required to decide the makeup of the contracting plan. They are:

1. Number of contracts - A project may be awarded to one contractor, as in the design-build process, or there can be two contractors, a design contractor and a construction contractor, or there can be thousands of contracts if the purchaser wants to split the work between that many contractors.

2. Selection criteria - A contractor may be selected based upon bid price or qualifications.

3. Contractual relationship - An 'agent' represents the purchaser's interest where a 'vendor' sells a product for a

price and has no purchaser interest. In a construction program, the definition and design phases are typically conducted using an agent relationship where the construction phase is usually a vendor relationship.

4. Terms of payment - Payment terms range from paying a contractor based on costs incurred (cost plus) to a fixed lump sum (firm fixed price) (38:7-9).

He goes on to say, "These decision categories are not either/or, they are spectrums. The decisions aren't crisp. There are shades of gray between the extremes" (38:7).

The primary determinant of how the four key decisions are made revolve around the degree of risk the government is willing to accept (32). There are two types of risk; the risk involved with the type of contractual relationship desired (agent or vendor) and the risk of putting together a contracting plan with various degrees of overlapping among the phases.

Contractual relationships range from agent to vendor. Typically, as the terms of payment approach a cost plus type contract, the more of an agent role the contractor will take on and the more risk is born by the government. An agent has limited risk since the government pays the cost and the contractor receives a predetermined fee for the service. In this relationship, the agent generally represents the employer's interests (32). Cost plus contracts are typically used when little is known about a project, consequently, a greater surveillance burden is placed on the

government to ensure the contractor holds costs to a minimum and the end product meets contract specifications (1:4-15 through 4-17). The definition and design phases of a construction program usually fit this category because construction requirements are unknown.

In the construction phase, where construction documents (specifications and drawings) traditionally exist, a Firm Fixed Price arrangement is usually used. Under a Firm Fixed Price arrangement, the contractor is required to deliver a defined product for a specified amount of money. The administrative burden is much lighter for the government because the government's interest lies only in the end product, not in the process, and whether or not the end product meets defined contract specifications (1:4-13 through 4-15;36:16-1).

CER must determine the amount of risk the government should accept based on each FMS case. If a weapon system is in research and development stages, for example, an agent relationship is desired with the CM because few requirements are known. The more developed a weapon system is, the less of an agent role is required.

Understanding the relationships between contract types, the risk involved, and government surveillance requirements is important to developing the proper contracting plan. Figure 4-1 summarizes these relationships.

The second type of risk revolves around the contracting plan developed. The traditional strategy is to award

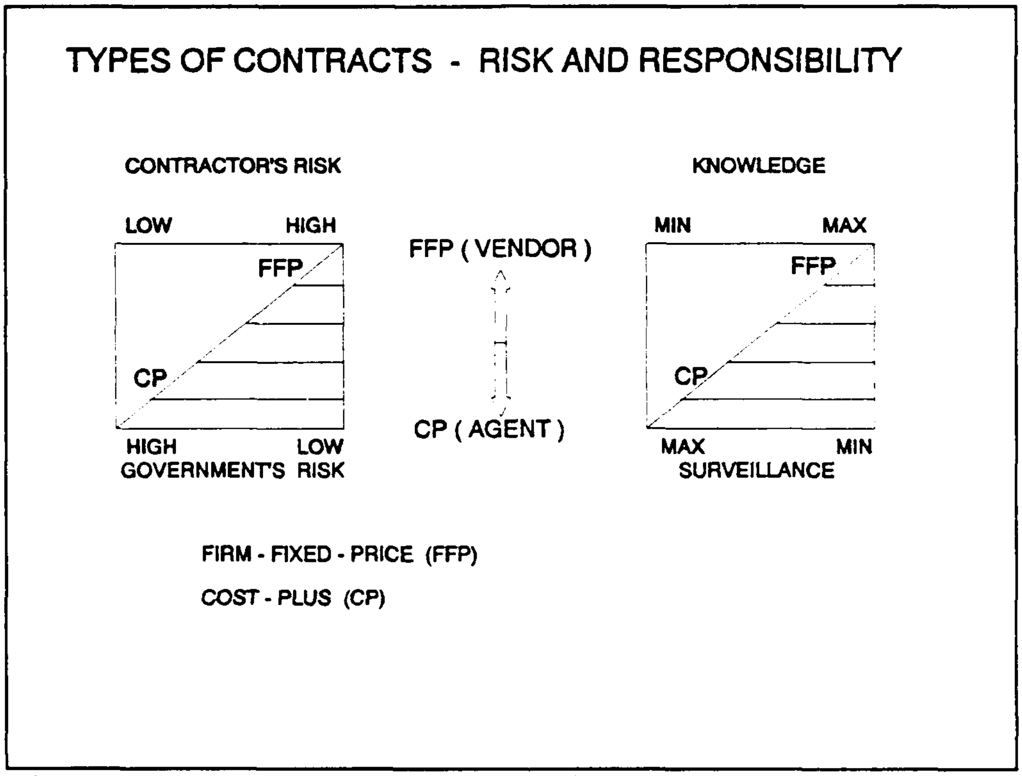


Figure 4-1. Contractual Relationships

contracts for construction when construction documents are complete. In this case, little to no overlap of the definition and design phases occur with the construction phase. As overlap of the three phases increases, more innovative contract strategies are needed because contracts are awarded before full knowledge of final requirements are known. The greater the overlap, the more risk the government accepts (32). Appendix B has a detailed discussion of innovative versus traditional contracting strategies on pages B:11-16.

In summary, CER must develop a contracting plan which incorporates the given conditions of a FMS case. It must decide the amount of risk the government is willing to accept and then develop either an innovative or more traditional contracting plan.

Contracting plan values range from traditional to innovative (33).

7. Responsiveness. Responsiveness is a measure of how critical a given situation requires CER and a CM to be able to adapt to change in the FMS construction program. Criticality is driven by elements such as the sensitivity of the diplomatic relationship between the U.S. and the foreign country, the importance placed upon the FMS program by the foreign country or the U.S. Government, and FMS program schedules. CER must assess how critical it is to respond to changes and then determine its own capabilities and the capabilities of potential CMs to respond to change on two tiers (31).

The first tier is CER's ability to get the construction program in motion through the planning functions addressed under the staffing parameter. In addition, CER must assess the capability of potential CMs to begin design efforts on the construction program and their ability to incorporate design changes throughout the design process.

The second tier involves CER and a potential CM's ability to act upon changes to a construction program when the program is in motion. Changes come from various sources

such as FMS program managers, host country change requests, and construction field changes identified from construction site managers (31). If responsiveness is assessed to be critical, CER must determine the capability of the construction monitoring staff to identify and communicate changes to the CM and a potential CMs ability to implement the changes to construction activities.

During the Peace Shield program in Saudi Arabia, construction changes were prolific because design and construction activities began before the facility design criteria was fully established. In order to avoid stop work conditions at construction sites, a two-part change order system was established. Negotiations for the construction changes were conducted after the change was completed by the construction contractor to determine an equitable adjustment to the contractor. In any construction program, two-part change orders are the least desirable method of handling change orders because it costs the government more than up-front negotiations with the construction contractor (5;31).

The reason for deciding to use two-part change orders was that follow-on system support programs were dependent on construction completion. Delays in the construction program would have meant delays in these follow-on contracts with associated costs to those programs. The determination was made that the cost to delay follow-on programs was greater than the cost of two-part change orders. In the words of Rusty Myers, Deputy Director, CER, "Many times you'll make a

customer oriented decision that is not necessarily a smart construction management decision" (31).

Responsiveness values can range from non-critical to critical (33).

Parameter Assessment Cuide

With a range of values known, each parameter can be graphically represented on a continuum. Figures 4-2, 4-3, and 4-4 represent a Parameter Assessment Guide which consolidates parameter continuums into one concise document that can be used by CER to assign a relative value to each parameter and applicable parameter elements. Supporting comments can be annotated alongside each continuum. The Parameter Assessment Guide provides a systematic approach to perform a situation analysis and provides a consolidated initial condition assessment to use in selecting a construction delivery schedule.

Strategy Heuristics

With a situation analysis completed, CER must then use the information to select a construction delivery strategy. This section determines rules-of-thumb, or heuristics, used by CER personnel to prioritize and weight the parameters assessed during the situation analysis tc determine how far the situation deviates from some 'standard situation'. The two heuristics are:

1. Flexibility - the need to deviate from standard or routine design and construction practices tends to favor

PARAMETER ASSESSMENT GUIDE (1/3)

COMMENTS

CUST. ASSESS. (HOST COUNTRY INVOLVEMENT)

NONE — COMPLETELY

CUST. ASSESS. (AIR BASE PLANNING CONCEPTS)

SIMPLE — ADVANCED

CUST. ASSESS. (QUALITY EXPECTATIONS)

LOW — HIGH

CUST. ASSESS. (EXISTING SITE CONDITIONS)

BARE SITE — DEVELOPED

CUST. ASSESS. (EXISTING SITE CONDITIONS, IF DEVELOPED)

UNCONGESTED — CONGESTED

CUST. ASSESS. (SKILL AVAILABILITY)

NONE — ALL

Figure 4-2. Parameter Assessment Guide (1/3)

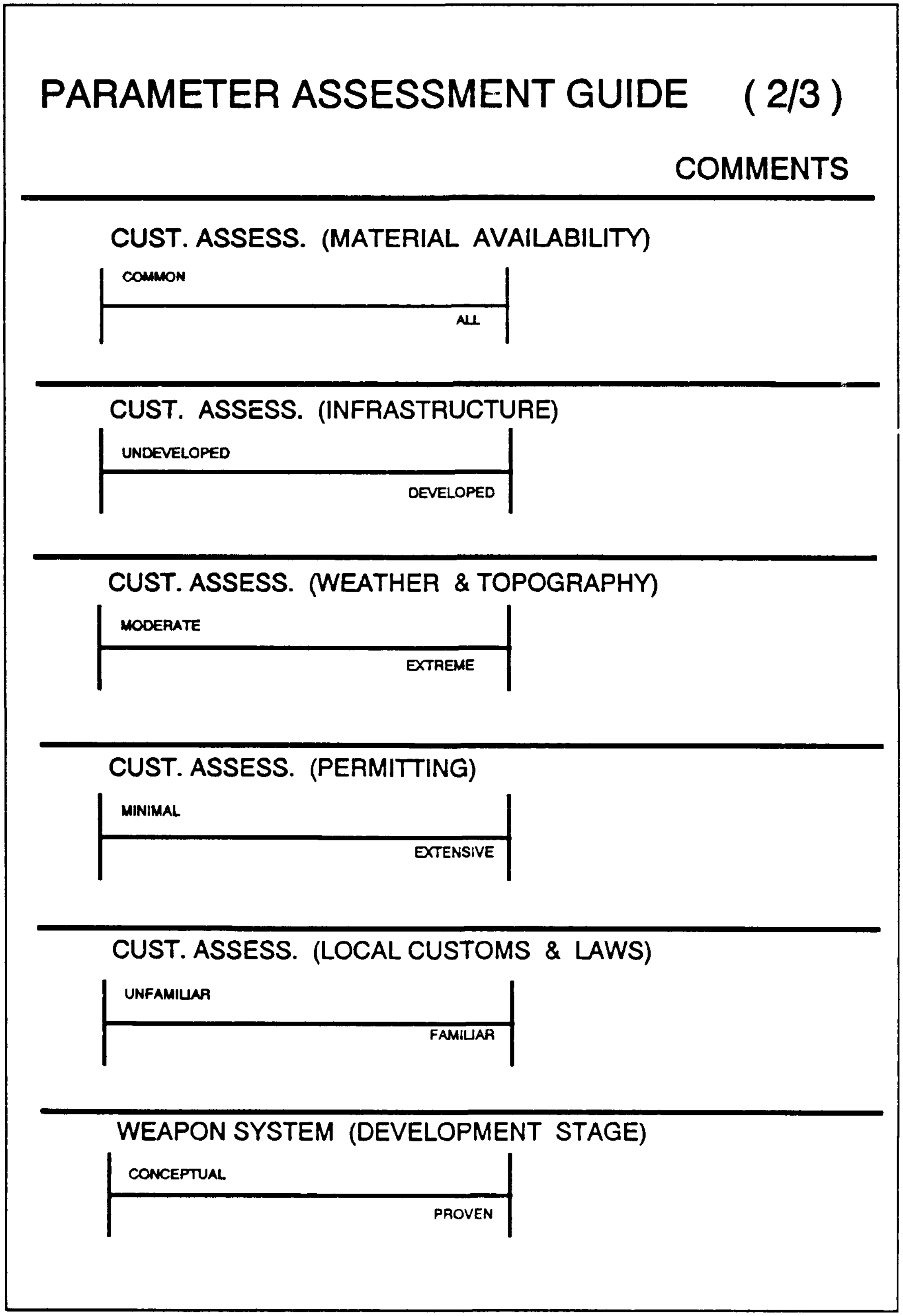


Figure 4-3. Parameter Assessment Guide (2/3)

PARAMETER ASSESSMENT GUIDE (3/3)

COMMENTS

WEAPON SYSTEM (DESIGN COMPLEXITY)

STANDARD — COMPLEX

POLITICAL ENVIRONMENT

DOD CHOOSES — CER CHOOSES

PROGRAM SCHEDULE

CONDENSED — AMPLE TIME

STAFFING

NONE — EXISTING ADEQUATE

CONTRACTING PLAN

TRADITIONAL — INNOVATIVE

RESPONSIVENESS

NON-CRITICAL — CRITICAL

Figure 4-4. Parameter Assessment Guide (3/3)

private industry as the construction delivery strategy.

2. Technology - Increased weapon system design complexity tends to favor private industry as the construction delivery strategy.

Generally speaking, a construction program that has characteristics of being straight forward, routine, and non-complex will tend to be a standard situation. A construction program with unique requirements or complex coordination issues requires more flexibility to deal with the unusual conditions. Unless a particular FMS construction program differs noticeably from the standard situation, AF policy will normally direct that the COE or NAVFAC should be used as the construction delivery strategy. The more that the parameters differ from a standard situation, the more the situation favors private industry (25;48).

When researching these heuristics, no general guidelines could be applied to distinguish between using a private architectural engineering (AE) firm and a weapon supplier. Both of these strategies were viewed as possessing similar characteristics. Consequently, AE firms and weapon suppliers are combined into one designation, 'private industry'. In addition, as was indicated in Chapter II, the purchasing country may choose to perform the role of CM, or the purchasing country may be asked to perform the role of CM after the customer assessment determines the capability exists. Determining when the

purchasing country should be requested to perform the CM role based on a customer assessment is not considered in this research. The analysis only considers the weighting to favor either the COE and NAVFAC or private industry.

Two heuristics are used to determine how far a FMS construction program deviates from the standard situation; flexibility and technology. Information presented in this section was determined by personal interviews with CER management and results received from distributing the Parameter Assessment Guide to CER staff with instructions to evaluate each parameter as conditions approach each end of the continuum and provide a judgement as to which construction delivery strategy, the COE and NAVFAC or private industry, is preferred. Conclusions drawn result from analyzing and summarizing the information received from the personal interviews, returned Parameter Assessment Guides, and comments received pertaining to particular parameters.

1. Flexibility. Flexibility is the ability to deviate from standard or routine procedures common in the construction industry. As the need for flexibility increases, private industry is preferred as the construction delivery strategy. Flexibility needs are driven by most of the parameters identified in the Parameter Assessment Guide, including the parameter that drives the technology heuristic (design complexity). Because of this, flexibility is the primary heuristic CER uses to decide on a construction

delivery strategy. As the need for flexibility diminishes, technology may become the driving heuristic as design complexity approaches 'complex' on the continuum and other parameters approach standard conditions. The following parameters determine the need for flexibility. For each parameter, the continuum value requiring more flexibility is presented first with comments to support the private industry preference. As the continuum value moves toward the need for less flexibility, the COE or NAVFAC is the preferred construction delivery strategy because of AF policy.

A. Schedule. As the program schedule is condensed, private industry is preferred as the construction delivery strategy. Comments from CER personnel indicate that the program schedule is considered the most important parameter to assess because it drives the other parameters closer to either extreme on the continuum. As the program schedule becomes condensed, design and construction activities must proceed faster than under normal conditions. As the program schedule begins to provide ample time, design and construction activities can proceed at a more standard pace. When the program schedule provides ample time for the construction program, the COE or NAVFAC is preferred.

B. Staffing. When no staff are present in a purchasing country, private industry is preferred as the construction delivery strategy. The two issues of concern are CER's ability to provide staff and the CM's ability to

provide staff. Comments from CER personnel indicate that CER's ability to provide staff is not a consideration in selecting a construction delivery strategy because this requirement is not dependent on the strategy selected. When a construction schedule is condensed, private industry has the ability to provide design and construction management staff quicker than the COE or NAVFAC. If any CM is present in the purchasing country, that CM is preferred. If both a private industry firm and the COE or NAVFAC are present, the COE or NAVFAC is preferred.

C. Contracting Plan. As the contracting plan moves toward an innovative approach, private industry is preferred. Comments from CER personnel indicate that private industry has the capability to manage more overlap of the definition, design, and construction phases of a construction program than does the COE or NAVFAC. As the schedule becomes more condensed, more flexibility is required to overlap the three phases, thus private industry is the preferred construction delivery strategy. The COE or NAVFAC is preferred if a traditional contracting plan is used.

D. Weapon System. The two aspects of a weapon system assessment, development stage and design complexity, are viewed as equally important to selecting a construction delivery strategy.

1. Development Stage. Private industry is preferred for less developed weapon systems. Comments from

CER personnel indicate that an undeveloped weapon system will require more overlap between the planning, design, and construction phases of a FMS construction program. A greater amount of overlap, as compared to a standard situation, requires more innovative contracting options because of more unknown requirements and thus favors private industry as a construction delivery strategy. As the weapon system approaches the developed stage, the COE or NAVFAC is preferred.

2. Design Complexity. Private industry is preferred as design complexity increases. Comments from CER personnel indicate that as design complexity increases, greater design expertise is required. Private industry has the ability to acquire this expertise better than the COE or NAVFAC. As design complexity becomes standard, the COE or NAVFAC is preferred.

E. Customer Assessment. The two aspects of customer assessment, requirements and condition survey, are not differentiated for determining a construction delivery strategy. Consequently, all of the parameters for customer assessment are discussed in the same order as listed on the Parameter Assessment Guide.

1. Host Involvement. No conclusions could be drawn from the data. No strategy was preferred at either end of the continuum.

2. Air Base Planning Concepts. As air base planning concepts become more advanced, private industry is

preferred. Comments from CER personnel indicate that more advanced air base planning concepts create greater design complexity which may require more design expertise. Private industry has more flexibility to gain this expertise than the COE or NAVFAC. As air base planning concepts become simplified, the COE or NAVFAC is preferred.

3. Quality Expectations. As quality expectations increase, private industry is preferred. Comments from CER personnel indicate that private industry is focused on higher quality levels because their existence depends on it for repeat business in the private sector. The COE and NAVFAC have a more process-oriented approach toward quality. As quality expectations lessen, the COE or NAVFAC is preferred.

4. Site Conditions. The information indicates that as site conditions approach either bare site or congested conditions, private industry is preferred. Comments from CER personnel indicate that both situations reflect the need for more flexibility in responding to the conditions and that more coordination requirements exist at both of these extremes. Private industry is able to respond to this type of situation better than the COE or NAVFAC. The COE or NAVFAC is preferred when site conditions are developed and uncongested.

5. Skill Availability. No conclusions can be drawn to prefer any strategy as skill availability approaches 'none available'. Comments from CER personnel

indicate that if there are no skill levels available, private industry may be able to import required skills faster, but the COE or NAVFAC can probably get support from USG agencies if importing difficulties arise. If all skill levels are available, the COE or NAVFAC is preferred.

6. Material Availability. No conclusions can be drawn as material availability approaches only common materials available. Comments from CER personnel indicate that private industry may be able to respond better than the COE or NAVFAC, but assistance from USG agencies when importing difficulties arise may provide better response capability to the COE or NAVFAC. If all materials are available, the COE or NAVFAC is preferred.

7. Infrastructure. As the country's infrastructure becomes less developed, private industry is preferred. Comments from CER personnel indicate that more coordination is required to support construction activities under less developed infrastructure conditions. The COE or NAVFAC is preferred as the infrastructure becomes more developed.

8. Weather and Topography. As weather and topography approach extreme conditions, private industry is preferred. Comments from CER personnel indicate that more extreme conditions require greater expertise to coordinate and plan activities. As conditions become moderate, the COE or NAVFAC is preferred.

9. Permitting. No conclusions could be drawn from the data. No strategy was preferred at either end of the continuum.

10. Local Customs and Laws. No conclusions could be drawn from the data. No strategy was preferred at either end of the continuum. Comments from CER personnel indicate, however, that the COE, NAVFAC, or a private firm is preferred if already established in the country.

F. Responsiveness. As responsiveness becomes more critical, private industry is preferred. Comments from CER personnel indicate that private industry tends to be able to respond to design and construction changes throughout a construction program better than the COE or NAVFAC. CER's ability to respond did not affect the decision because regardless of which strategy is selected, CER must be able to respond in the same manner. As responsiveness becomes non-critical, the COE or NAVFAC is preferred.

2. Technology. The technology heuristic is driven by weapon system design complexity. As design complexity increases, there is a tendency to require nonstandard construction methods or a requirement to install specialized equipment and materials. Private industry can provide nonstandard construction methods and specialized equipment and materials better than the COE or NAVFAC. Design complexity also contributes to the flexibility heuristic. As the need for flexibility decreases because of more

standard conditions, design complexity may remain high which then gives more weight to the technology heuristic as the driver in selecting private industry as the construction delivery strategy (24;31;43;44).

Summary

This chapter represents the knowledge acquisition stage in developing a decision support system. The parameters which CER must evaluate to perform a situation analysis and a Parameter Assessment Guide are developed. The parameters are; customer assessment, weapon system, political environment, program schedule, staffing, contracting plan, and responsiveness. Then, heuristics CER personnel use to select a construction delivery strategy are developed. They are; flexibility and technology. The need for flexibility is determined by evaluating all of the parameters, except political environment, and technology is determined by the weapon system design complexity. As the need for flexibility increases, private industry is preferred as the construction delivery strategy. As the need for flexibility decreases, technology may drive the decisic . If neither the need for flexibility nor technology needs are high, AF policy directs the COE or NAVFAC to be preferred as the construction delivery strategy.

V. Building the Decision Support System

Overview

This chapter describes the building of the decision support system (DSS) for use by the Directorate of FMS Construction Engineers (CER) and provides instructions on how to use it as a tool to select a construction delivery strategy for FMS construction programs.

Development

The last step in building this DSS is to format the information gained in the knowledge acquisition stage into a framework that can be used by CER in selecting a construction delivery strategy. This section discusses the formatting process.

During the knowledge acquisition stage, it was discovered that as parameter values move to a particular end of the continuum, private industry becomes the preferred construction delivery strategy over the Corp of Engineers (COE) or the Naval Facilities Engineering Command (NAVFAC). On the other end of the continuum, the COE or NAVFAC is preferred because of AF policy. Using this information, it is possible to construct a DSS to assist CER in selecting a construction delivery strategy for FMS construction programs when the political environment does not specifically direct the use of the COE or NAVFAC.

The primary heuristic in selecting a construction delivery strategy was determined to be flexibility. As the need for flexibility increases, private industry becomes the preferred construction delivery strategy. Chapter IV prioritizes the parameters that determine flexibility requirements. In the absence of a high flexibility requirement, technology requirements, based on the weapon system design complexity parameter, may become the driving heuristic to select private industry as the preferred construction delivery strategy. If neither flexibility nor technology are determined to have high requirements, then AF policy directs the use of the COE or NAVFAC as the construction delivery strategy.

A DSS can be constructed by consolidating the most important parameters onto one page to give one picture of the initial conditions as determined by the situation analysis. Figure 5-1, Strategy Selection Guide, represents a DSS which can assist in selecting a construction delivery strategy. Parameter extreme values have been arranged so that parameter assessments reflecting a more flexible requirement or higher technology requirement will move toward the left end of the scale for each parameter. The relative degree of approaching the left extreme determines the relative weight given to using private industry as the construction delivery strategy. As a parameter value moves to the right, the COE or NAVFAC is preferred.

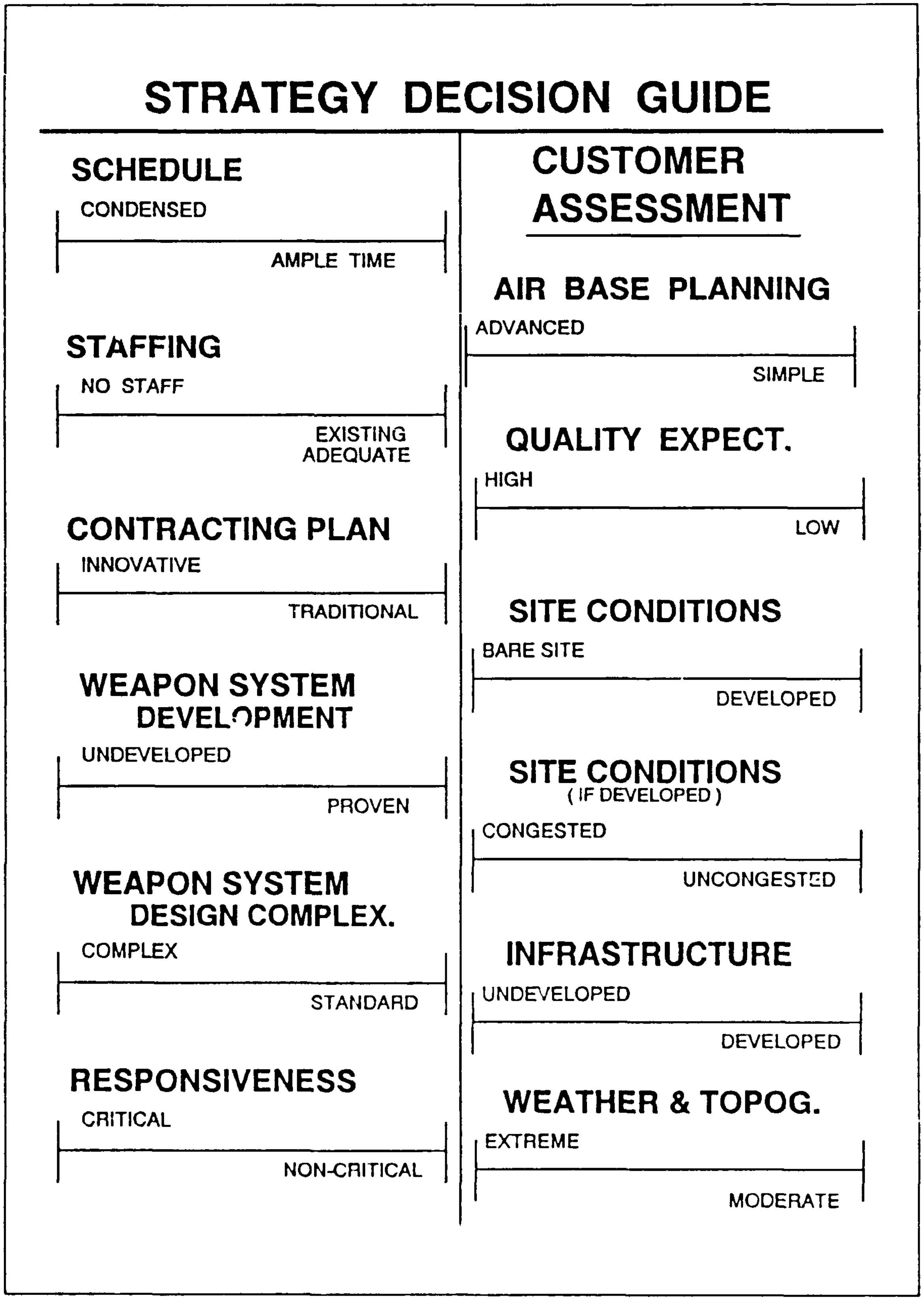


Figure 5-1. Strategy Selection Guide

Values for the Strategy Selection Guide are arrived at by conducting a thorough situation analysis using the Parameter Assessment Guide. This analysis will provide the information to determine relative values to be assigned to each parameter as well as appropriate comments to indicate how the assignment was made. The values assigned to the Parameter Assessment Guide can then be transferred to the Strategy Selection Guide to assist in selecting a construction delivery strategy.

Directions for Using the DSS

1. Conduct an initial situation analysis based on the parameters discussed in Chapter IV.

2. Indicate on the Parameter Assessment Guide a relative position on the continuum for each parameter.

3. Transfer the value from the Parameter Assessment Guide to the Strategy Selection Guide.

4. Using the strategy heuristics developed in Chapter IV, evaluate the parameters to select a construction delivery strategy. Generally, as values move toward the left, private industry becomes the preferred construction delivery strategy. As the values remain toward the right, AF policy directs the use of the COE or NAVFAC.

Summary

This chapter describes how a DSS is built to assist CER in selecting a construction delivery strategy. Information

gained from the knowledge acquisition stage is used to build the DSS.

VI. Recommendations

Overview

This chapter recommends two additional research projects to enhance this research and it recommends additional uses for the Parameter Assessment Guide presented in Chapter IV.

Recommendations for Further Research

There are two research projects which should be conducted to further support this research:

1. Development of a computerized expert system should be accomplished using the knowledge acquisition and decision support system development stages of this research.

2. The strategy heuristics developed in chapter IV can be used as a starting point to determine capabilities of the Corp of Engineers (COE), the Naval Facilities Engineering Command (NAVFAC), and private industry in performing FMS construction projects. Information discovered in this research should be used in conjunction with the following references:

A. Stollbrink, Captain Michael. 'A Study of User Involvement in the Military Construction Program Process'. MS Thesis, School of Systems & Logistics, AFIT, Wright-Patterson AFB OH, September 1986.

B. Headquarters Air Force Engineering and Services Center. 'Project Image: Analysis of Engineering

Functions'. Contract No. F-98635 - C- 0252, Tyndall AFB FL, October 1986.

C. Marcos, Bernard, Jr. 'A Study of the Perceptions of Roles, Responsibilities, and Problem Areas During Facility Transition in the Military Construction Program'. MS Thesis, School of Systems and Logistics, Air Force Institute of Technology (AU), Wright Patterson AFB OH, September 1987.

D. Dutcher, Captain Gerald B. 'An investigation Concerning Perceptions of Military Construction Program Effectiveness by the AFRCEs, the MAJCOM, and the Bases'. MS Thesis, School of Systems and Logistics, Air Force Institute of Technology (AU) Wright-Patterson AFB OH, September 1986.

E. Larson, Captain Ruth I. 'An Analysis of the Programming of Facilities to Support Deployment of Major New Weapon Systems'. MS Thesis, School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1985.

F. Poe, General Bryce and Lieutenant General Devol Brett. 'Observations on USAF Construction Programs with Emphasis on U.S. Army Corps of Engineers Involvement'. Special report for the U.S. Army Corps of Engineers, HQ USAF, Washington DC, 6 August 1985.

G. Sekiguchi, Captain Brian H. 'Evaluation of the Air Force as Design and Construction Agent in the

Military Construction Program'. MS Thesis, School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH, September 1988.

Additional Use of this Research

The information gathered to develop the parameters in Chapter IV are generic in nature. Every time the Directorate of FMS Construction Engineers (CER) is designated as the FMS construction program manager or design and construction agent, an initial situation analysis must be completed. The data gathered to support this initial analysis, as presented in the Parameter Development section of Chapter IV, can be used to systematically support the analysis.

Conclusion

This research builds a decision support system to assist CER in the selection of a construction delivery strategy. It first identifies, defines and determines extreme values for parameters which CER must evaluate to conduct a situation analysis for any FMS construction program. The parameters are customer assessment, weapon system, political environment, program schedule, staffing, contracting plan, and responsiveness. A Parameter Assessment Guide is then developed to guide CER in conducting a situation analysis. The Parameter Assessment Guide provides a picture of initial conditions CER must deal

with in the FMS construction program. After developing the parameters, heuristics are determined which CER uses to select the best construction delivery strategy given the initial conditions. The heuristics which CER use are flexibility and technology. Using these heuristics, a Strategy Selection Guide is developed which CER can use to assist in selecting a construction delivery strategy. All of the parameters, except political environment, carry weight in selecting a construction delivery strategy. The political environment parameter measures the degree of choice CER has in selecting a construction delivery strategy. The Strategy Selection Guide is the DSS that CER can use to assist in selecting the best construction delivery strategy for any given FMS construction program.

Appendix A: Overseas Designated DOD Construction Agents (29:E-1.9)

Department of the Army

Canada
  excluding: Newfoundland
Canal Zone
Egypt
Europe
  excluding: Spain
    Portugal
    Italy
    Greece
Greenland
Israel
Japan
  including: Ryukyu Island (Okinawa)
Korea
Marshall Islands
Middle East
  including: Entire Saudi Arabian Peninsula and Southern Asia, from Iran to Burma
Taiwan
Turkey

Department of the Navy

Atlantic Ocean area
Australia
Caribbean Sea area
Greece
Iceland
Indian Ocean area
Italy
Newfoundland
New Zealand
North Africa
  including: Somalia
    Kenya
  excluding: Egypt
Pacific Ocean area
  excluding: Marshall Islands
Portugal
  including: Azores
Republic of the Philippines
Southeast Asia
Spain

Appendix B: Contracting Plan

The following document, 'Project Delivery Schedule', is a handout which was presented by Mr Chuck Thomsen to MGT 422, Project Management Course, School of Civil Engineering and Services, Wright-Patterson AFB OH on 29 April 1991. It is a discussion of alternative methods of managing and contracting for design and construction and is attached in its entirety. The handout is not copyrighted as indicated on the letter from Mr Thomsen following this page.

Mr Thomsen is the President and CEO of 3D/International, the parent company of specialized subsidiaries providing architecture, engineering, construction management and environmental services worldwide.

Charles B. Thomsen FAIA
President

3D International
1900 West Loop South
Houston, Texas 77027 - 3292
Tel 713-871-7000
Fax 713-871-7456

July 30, 1991

Captain Devon Volks
5800 Access Road
Dayton, Ohio 45431

Dear Captain Volks:

The attached material on Project Delivery isn't copyrighted. You're more than welcome to use any part of it in anyway you'd like.

I'm flattered that you're interested.

Charles Thomsen /kp

CBT:kp

Project Delivery Strategy

A discussion of alternative methods of managing and contracting for design and construction.

Charles B. Thomsen, President & CEO, 3D/International

Introduction

Among the first decisions a client must make is the selection of a process for design and construction. The process will affect the financing, the selection of the project team, the schedule and the cost.

We have experience with all the processes. We have worked as architects, engineers, project managers, construction managers and design-build contractors. We have worked with fast-track, bridging and traditional processes. We have worked with GMP, cost-plus, target-price and lump-sum contracts.

They all work--and they can all fail. The right choice is governed by exigencies that surround an individual project.

Finally, the process only helps or hinders. The biggest issue is the quality of the people. With good people, any process can work. So *the most important part of the process governs* the selection of people and organizations.

Phases of design and construction

Design and construction can be divided into three distinct phases: project definition, design and construction. Each can be further subdivided.

These phases and sub-phases are distinguished from one another because they require different skills and technology. They are typically accomplished by different organizations or at least by different people in the same organization.

The phases can be overlapped, telescoped, combined, subdivided and regrouped, but they can't be eliminated. And if one phase or sub-phase is done poorly, the downstream phases are harder to do well.

There are three classic phases of design and construction.

1. Project definition: At 3D/I, we subdivide this phase into two rigorous activities.

- Discovery, the search for all relevant facts surrounding the project.
- Integration, a thorough description of the project and the plan (including an estimate of cost and time) for delivering it.

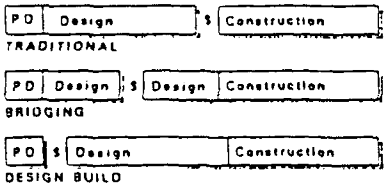
2. Design: Typically, design is divided into three phases.

- Schematic design, the basic appearance and plans.
- Design Development, a further evolution that defines the functional and esthetic aspects of the project.
- Construction drawings and specifications, the details of assembly and construction technology.

3. Construction: Construction can also be divided into several basic activities.

- Award, the bidding or negotiation of one or more contracts to construct all or part of the project.
- Procurement, the purchasing, negotiation, or bid and award of materials and subcontracts.
- Shop drawings, the final fabrication drawings for building systems.
- Fabrication, delivery and assembly, the manufacture and installation of the manufactured components of the building.
- Site construction, the labor-intensive field construction and the installation of systems and equipment.

When to make the deal



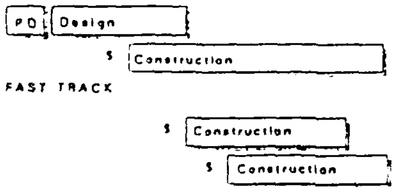
A contract ($ sign) may be awarded at any level of definition. The question is <u>when</u> you turn design over to the contractor.

A contract for design and construction may be awarded at any time.

○ **The traditional process** is common because most clients want to know exactly *what they are getting and what they must pay for it.* Contracts for construction are not let until design and construction drawings are complete. However, even with the traditional process, shop drawings are done by contractors. So it can be said that all of the common processes entail some portion of design being done by a contractor.

○ **Bridging** is a hybrid of design-build and the traditional process. Typically Bridging projects are bid with contract documents prepared by the client's AE that specify the project's functional and aesthetic requirements but define the details of construction with performance specifications. The project is bid and the Construction Documents are done by a design-build contractor or a general contractor with an AE as a subcontractor. This process allows owners to define requirements with their own AEs and allows contractors to influence construction technology, means and methods.

○ **Design-build** contracts are typically negotiated before project definition, or just after. All design and construction drawings are done by the design-build contractor. Design-build integrates construction knowledge into design. Some clients are troubled by having the same organization begin in an fiduciary role and then shift to the vendor role.



Fast-track is jargon for overlapping design and construction, and may be applied to any process--traditional, bridging or design-build.

○ **Fast-track** is *jargon for overlapping design and construction.* It may be done with the traditional process, bridging, design-build, or any other process to accelerate completion.

There is no technical reason not to overlap design and construction. The problem is contractual. When projects are fast-tracked, the final price is uncertain. The cost of downstream contracts is unknown when the first is awarded. Even if a contractor provides a GMP (guaranteed maximum price), it is for a product that has not been fully defined, so there are more opportunities for change orders than with complete construction drawings and specifications.

There are many ways to fast-track a project. For example, site work, shell and core, and interiors may be bid separately, resulting in three contracts. In a construction management process there may 40 prime construction contracts.

Contract Documents

Documents that describe what the contractor must deliver are required for a construction contract. Different countries and different industries have different traditions (and convictions) about the detail required for those documents. Typical documents are:

Construction documents and specifications. Most AEs in the U. S. believe that full construction drawings and specifications are required to adequately describe the project and make an enforceable fixed-price contract.

Different countries and different industries have different traditions (and convictions) about the detail required for contract documents.

A Bill of Quantities. In countries influenced by the British there are licensed professionals (Quantity Surveyors) who measure drawings, calculate the amount of each required material and then prepare a Bill of Quantities. Contracts are based on the unit cost of each building material. Unit price contracts are common for highway construction in the U.S. and most tenant fit-out in office buildings is done with unit price contracts.

Design development and specifications. In Japan, projects are usually bid with what we would call design development drawings (35-50% of the level of detail that is contained in a full set of U. S. construction drawings and specifications). Construction drawings are completed by design-build contractors who maintain a staff of architects and engineers. In France, there are AEs who do design work and other firms called *Bureaux d'Etudes* that do construction documents. The *Bureaux d'Etudes* may work for the owner or the contractor. The petrochemical industry in the U.S. and overseas also uses this approach.

Key decisions

The considerations surrounding a project should influence the project delivery strategy. Pressures on schedule, budget, the symbolic role or practical functionality of the design, the experience of the client's management, the project's oversight, or the legal regulation of procurement will influence strategy. So will tradition. Many times things are done simply because that's the way they have been done in the past. Strategy simply isn't considered.

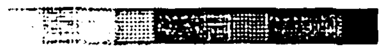
There are infinite variations in delivery strategy, but there are four basic decisions. They are:

1 Number of contracts
2 Selection criteria
3 Relationship of owner to contractor
4 Terms of payment

These decision categories are not either/or, they are spectrums. The decisions aren't crisp. There are shades of gray between the extremes.

Number of contracts

one many



NUMBER OF CONTRACTS

A project may be awarded to one contractor, as in design-build. In the traditional process there are two contractors: an AE and a construction contractor. (There are three with a project manager.) With a construction manager an owner may have contracts with as many as 40 prime subcontractors, or an owner may purchase building materials and equipment, and arrange multiple labor contracts. There may be thousands of contracts.

As the number of contracts increases, the opportunity to save time and money and improve quality also increases. So does risk.

With multiple contracts, an owner can fast-track a project (overlap design and construction). Direct purchase of labor and materials eliminates overhead markups. Unbundling design allows an owner to select specialists, and unbundling construction allows careful selection of specific manufacturers and trade contractors. So as the number of contracts increases, the *opportunity* to save time, money, and improve quality also increases.

So does risk. Owners who choose to manage multiple contracts must manage the contracts well or take the responsibility for management

failures. Consequently, most clients choose a construction manager[1] to help them if they use multiple contracts.

Selection criteria

SELECTION CRITERIA

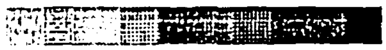
A contractor may be selected on the basis of price or qualifications. Clients often consider both and require a proposal (which could be a management plan or a design) *and* a price.

Typically, AEs are selected with an emphasis on qualifications, and construction contractors are selected on the basis of price. But there are clients who select AEs on price and those who select GCs on qualifications.

If a common product or service (easily defined in a bid document and easily evaluated when delivered) is to be purchased, there is little reason not to choose on the basis of a low price.

A selection based on qualifications, price or a combination is usually influenced by the kind of product or services to be bought. If a common product or service (easily defined in a bid document and easily evaluated when delivered) is to be purchased, there is little reason not to choose on the basis of price. But if the product or service is unusual or proprietary, or if wisdom, judgment or experience is required in a fiduciary role, selection is usually based on qualifications.

Contractual relationship



CONTRACTUAL RELATIONSHIP

An owner may view contractors in one of two ways: as an agent or as a vendor. An agent represents the owner's interest and has a fiduciary responsibility. A vendor is a salesperson who sells a specified product for a price. Agents tend to work for a fee and are usually selected on the basis of qualifications. Vendors sell a product for a price and are usually selected on the basis of cost.

Typically, AEs are viewed at the agency end of the spectrum and contractors are at the vendor end. But there are exceptions. Some clients ask contractors to act as their agents in managing construction and treat AEs as a vendor of plans and specifications.

[1] The term construction manager is used synonymously with project manager in many situations. Often a *project manager* is used with the traditional process, a construction manager with multiple-contract fast-track, or a GC may take on the title of onstruction manager with a fast-track GMP contract. The same company may provide all three kinds of services for different clients.

When clients need help in the form of wisdom, judgment, talent or creativity, they typically choose an agent (a fiduciary) relationship. Clients that know what is required typically form vendor relationships.

When clients need help in the form of wisdom, judgment, talent or creativity, they typically choose an agent (a fiduciary) relationship. Clients that know what is required typically form vendor relationships. There is a built-in conflict of interest if a contractor is to be both agent and vendor. For instance, an AE hired to design a project is often not allowed to bid for the construction work. A contractor required to deliver a building for a fixed price will not be assigned the role of inspecting construction or determining the project's requirements.

Terms of payment

TERMS OF PAYMENT

At one end of the spectrum, you can choose to pay a contractor based on the contractor's cost—as they are incurred. At the other end is a fixed lump sum. Contracts tend to move from cost plus to lump sum as the details of the work become clearly understood. In between, there are variations. The common arrangements are:

Contracts tend to move from cost plus to lump sum as the details of the work become clearly understood.

- **Cost-plus.** Contractor is paid actual costs plus a fixed or a percentage fee.
- **Cost-plus with target price.** Contractor is paid actual costs plus a fee. However, a target price is set, and the contractor will share in the savings or the overrun. The target price is modified by change orders as the project progresses.
- **Cost-plus with a guaranteed maximum price.** Contractor is paid actual costs plus a fee. However, a maximum price is set, and the contractor will share in the savings but will pay all of the overrun. The GMP[2] is modified by subsequent change orders.
- **Unit price.** Contractor is paid a predetermined amount for each unit of material put in place (or removed).
- **Fixed price.** Contractor is paid a fixed sum for the work.

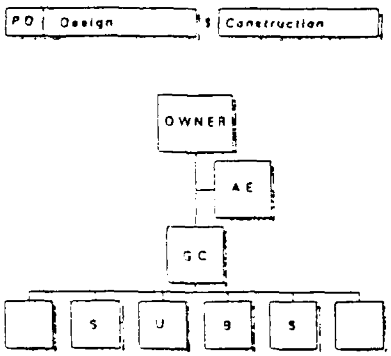
These payment terms may be combined in a single project. Often a building construction contract will be a lump sum but may have unit price provisions for something such as rock removal during excavation or tenant work during lease-up. Change orders may be based on a cost-plus arrangement.

[2] Many people use the term GMP synonymously with fixed price. That is incorrect. A GMP is a lid on a cost-plus contract with a defined scope. It is *more* susceptible to change orders than a lump sum because it is typically given before construction drawings are complete. It is one of the most difficult of all contracts to manage. It has the problems of both lump sum and cost plus contracts. There will probably be more change orders to negotiate. There will also be many issues over the definition of "cost," e.g., rental rules on contractor-owned equipment or ownership of workman's compensation refunds or penalties.

Typical project delivery methods

Although the variations are infinite, some processes are more common than others. The most common include the traditional process, construction management and fast-track, and design-build.

The traditional process



Most American construction follows the simple logic of design, bid, build. An AE is hired to define the owners needs, design the appropriate building, prepare construction drawings and specifications, and administer construction. These drawings and specifications serve two purposes. They provide guidelines for construction, and they define what the contractor is to deliver for the price.

The drawings are made available to contractors who bid. Bidders are sometimes prequalified and shortlisted and usually provide a bond. Typically, the low bidder is awarded the work.

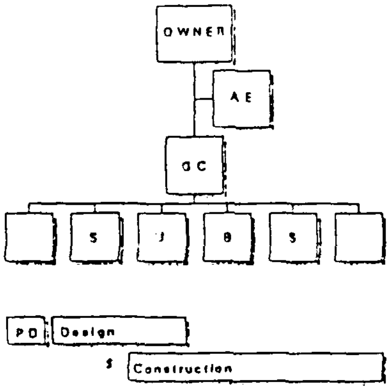
The AE is typically at the agent end of the spectrum, the construction contractor is at the vendor end. The process is simple to manage. Roles are clear, the process is universally understood. Since the client has a defined requirement and a fixed price, it is prudent.

The flaws are also simple. It takes too long because construction can't start until all design is complete, and the project may suffer from a lack of practical input on cost or constructibility from contractors or subcontractors.

CM and fast-track

Many clients look for ways to accelerate schedules. Fast-track–starting construction before finishing design–is a common technique.

The problem with fast-track is inherent in its advantage. Since construction is started before design is complete, the owner lacks the security of a fixed price based on complete construction documents. There is no *contractual* assurance that the project will be completed within the budget. Two common procedures are used to deal with this problem. Neither is foolproof.



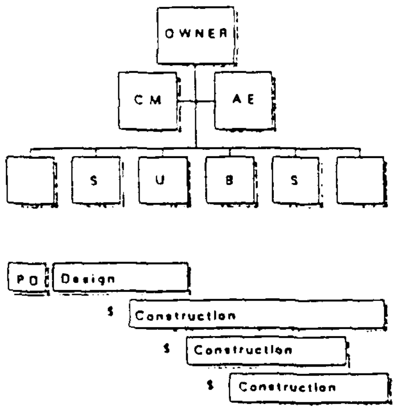
CM FAST TRACK Negotiated Contract with GMP

1. Negotiated general construction contract with a guaranteed maximum price (GMP). Many general contractors have offered construction management services to an owner under a cost-plus guaranteed maximum price (GMP) contract. The argument is simple: Since the project is not fully designed when construction begins, the contract should be cost-plus. But to give the client security that the project will be built within the budget, the contractor will provide a GMP.

The promise of a guaranteed maximum price has a *wonderful sound*. However, the concept is illogical. The reason for the guaranteed maximum price is that the drawings are *incomplete*. So the guaranteed maximum price is for what? As design is completed there is ample opportunity for an aggressive or inept contractor to make claims for change orders that are "out of the original guaranteed scope." The GMP is a defined price for an undefined product.

Despite its logical flaws, the process works for developers or small, experienced, private-sector clients who can select contractors on the basis of qualifications and integrity, reward them with repeat work and manage them vigorously. The process also works best for simple office buildings that are well understood by all (the client, the AE and the contractor).

Cost-plus with a GMP is more apt to fail with complex buildings, the public sector or large corporate or institutional clients. First, it is difficult for these kinds of clients to award and administer cost-plus contracts. Second, these clients are particularly vulnerable to claims and change orders. And, most important for clients with deep pockets, awarding a contract on the basis of incomplete documents increases vulnerability to claims and litigation.



CM FAST TRACK Professional CM

2. Professional construction manager with multiple prime contracts. In essence, the role of the general contractor as a vendor (the manufacturer and seller of the building) is eliminated and replaced with a construction manager who manages the project in an agency (fiduciary) capacity.

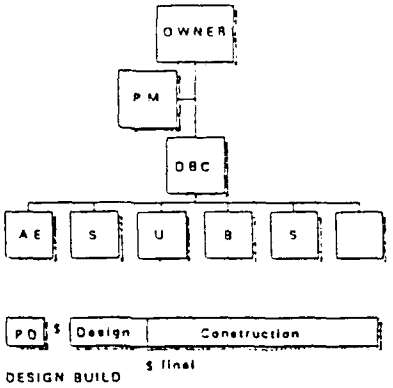
Typically, a professional CM bids construction work in small trade contracts, beginning with the most critical items first. A conservative strategy is developed to ensure that there won't be downstream overruns. One common strategy is to award only the shop drawing phase of early trade contracts. Final notice to proceed with fabrication or construction is delayed until most of the work is bid and most of the project cost is pinned down.

The secret of a successful fast-track project is not the intellectual elegance of a sound contract, nor does anyone believe it's an unflawed process. Success can only come from the quality of the management team. The professional approach works better for the public sector because governments can select professionals on the basis of qualifications to replace the function of a general contractor. Even if *source selection procedures*[3] are used to select construction contractors on the basis of qualifications, the government has difficulty exercising the management sanctions that are the necessary stick to make a cost-plus GMP contract work.

On government work, the subcontracts are directly with the owner. But in the private sector, the CM typically holds the subcontracts for the owner.

[3] *The term for government contracting procedures that consider qualifications as well as price.*

Design-build



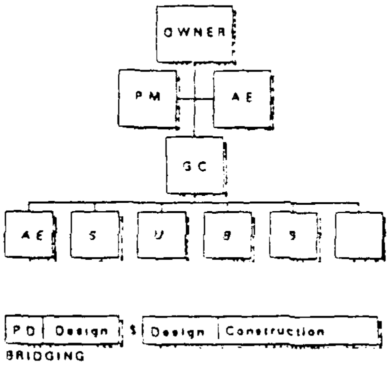
With design-build, a single company provides both design and construction. Responsibility can be centralized, design and construction can be overlapped, and design is improved with input from construction experts.

More projects would be design-build if it weren't so difficult to formulate an enforceable price before design. Most owners want to know what their building will cost before they hire a contractor. The paradox: It's hard to define the work to be done for an agreed upon price without design. If design is done, then it's not design-build.

Some design-build companies work under an AE fee with a target price until the design is set. They then negotiate a final price. They agree that the owner may obtain prices from other contractors as well.

In this kind of arrangement, the design-build contractor begins in an agent role and changes to a vendor role. Many do so with integrity. But many clients feel that it's unwise to hire a contractor to define a product as an agent that they will then sell as a vendor.

Bridging



Bridging is the U.S. name for a design-build process common in Europe and Japan, and the petrochemical industry.

In the bridging process there are two sets of AEs. The first AE works for the owner. The drawings used for bid documents are about 35-50% as complete as is usual. Bid documents define the functional and aesthetic characteristics of the project. They include drawings and a combination of performance and traditional specifications, but the documents leave considerable latitude for contractors to look for economies in construction technology when they put together their bids.

The project is bid by design-build contractors or to general contractors who have an AE for a subcontractor. The contractor's AE (the second AE) does the final construction drawings and specifications, and is the Architect of Record. Typically, construction is not begun until the final construction drawings are complete and it is clear that there are no misunderstandings about what was intended by the bid documents. If there is disagreement the owner has the right to use the plans for competitive bids.

Bridging has the beneficial attributes of the traditional process: a bonded, enforceable lump sum contract and complete contractual documentation before construction starts. It also has the beneficial attributes of design-build: centralization of responsibility and integration of practical construction knowledge into final engineering. Bridging also reduces (by about half) the time and cost required to obtain a construction contract with an enforceable lump sum price.

By centralizing responsibilities during construction, bridging minimizes the opportunity for contractor claims based on errors or omissions in the drawings or specifications. It also centralizes the responsibility for correction of post-construction faults in the design or construction.

The biggest problem with bridging is that it's new and uncommon. The construction industry is large with many contractors, AEs, consultants, subcontractors, manufacturers and suppliers. Tradition is the great facilitator. When you change the process, you must work hard to explain the new, less familiar process.

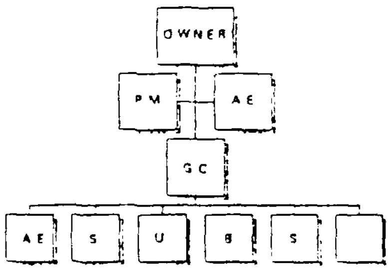
Trends

During the last two decades, innovation in project delivery methods has been driven by three common objectives:

1. A desire to make final construction costs predictable.

2. A desire to temper the creative acts of design with the practicalities of construction technology.

3. A desire to avoid the swamp of lengthy, costly claims and litigation so common in the design and construction of buildings.



Clients have frequently added professional project managers to the process of design and construction to improve reliability and meet these objectives.

The idea is to select an organization with experience in construction to improve cost, schedule and quality control; improve the constructibility of the design; develop risk management and claims protection programs; improve other management controls to smooth the process; and improve field management.[4]

Often these project management teams will add other refinements to the process such as:

○ Purchase and assignment. The project manager may purchase major items of manufactured equipment, long-lead items or even subcontracts, and assign them to the eventual general contractor.

○ Unbundling and repackaging. Sophisticated clients and their PMs are unbundling the design process just as construction managers unbundled the construction process. Many projects have a planner, a design architect, a construction documents architect and separate architects for different aspects of the interiors.

[4] Although it is not yet common in the industry, 3DI has also emphasized the project definition phase as an important project management service.

3D/International, Inc.

3D/International is the parent company of specialized subsidiaries providing architecture, engineering, construction management and environmental services worldwide.

Recent significant projects include the renovation of the Pentagon, Washington, D.C.; the headquarters for the Department of Transportation, Washington, D.C.; the Texas State Capitol, Austin, Texas; the Dorchester Hotel and Harrods Department Store, London; and a operations center for Wells Fargo in Sacramento, California.

While two or more 3D/I companies may work together on a given project, each subsidiary maintains its own client base and manages its own operations. Subsidiaries can provide a single service or integrate into large, multi-disciplined teams as projects demand.


Chuck Thomsen

Charles B. Thomsen is President and CEO of 3D/International, Inc. 3D/I is the parent of companies that provide services in architecture, engineering, construction management, construction and environmental engineering. 3D/I has twenty offices throughout the U.S., the Middle East, the Pacific and Europe.

Mr. Thomsen studied at the University of Minnesota, the University of Oklahoma (Bachelor of Architecture, 1957) and the Massachusetts Institute of Technology (Master of Architecture, 1963). He was a member of the architecture faculty at Rice University and taught at Boston Architectural Center and Columbia University. He lectures annually at Harvard and the Air Force Institute of Technology. He served in the Marine Corps.

He has written two books on contracting methods, project delivery strategies and management: *CM: Developing, Marketing, & Delivering Construction Management Services* (McGraw-Hill 1982) and *Managing Brainpower* (AIA Press 1989). He has worked on hundreds of projects in twenty-two countries. Several exceeded $1 billion (including the world's largest lump sum bid). He has personal experience in nearly every conceivable form of project delivery.

3D/International, Inc.
1900 West Loop South
Suite [illegible]
Houston, Texas [illegible]
[illegible]
FAX [illegible]

Houston, Texas; Alexandria, Virginia; San Antonio, Texas; Seattle, Washington; Washington, D.C., Sacramento, California; Irvine, California; Phoenix, Arizona; Dayton, Ohio; Flagstaff, Arizona; Cincinnati, Ohio; Amelia, Louisiana; London, England; Hong Kong, Riyadh, Saudi Arabia

Appendix C: Acronyms

AE	Architectural Engineering Firm
AECA	Arms Export and Control Act
AF	Air Force (See also USAF)
AFIT	Air Force Institute of Technology
AFLC	Air Force Logistics Command
AWACS	Airborne Warning and Control System
CER	HQ AFLC, Directorate of FMS Construction Engineers
CM	Construction Manager
COE	Corp of Engineers
CONUS	Continental United States
CPM	Construction Program Manager
DCA	Design and Construction Agent
DISAM	Defense Institute of Security Assistance Management
DOD	Department of Defense
DSAA	Defense Security Assistance Agency
DSS	Decision Support System
DTIC	Defense Technical Information Center
EAF	Egyptian Air Force
FAA	Foreign Assistance Act
FMS	Foreign Military Sales
FMSA	Foreign Military Sales Act
FMSMP	Foreign Military Sales Management Plan
ILC	International Logistics Command

LOA	Letter of Offer and Acceptance
LOR	Letter of Request
MAJCOM	Major Command
MDE	Major Defense Equipment
MILCON	Military Construction
MILDEP	Military Department
NAVFAC	Naval Facilities Engineering Command
OSD	Office of the Secretary of Defense
P&A	Price and Availability
P&R	Planning and Review
SA	Security Assistance
SAF	Secretary of the Air Force
SAO	Security Assistance Organization
SECDEF	Secretary of Defense
SME	Significant Military Equipment
USAF	United States Air Force
USG	United States Government

<u>Bibliography</u>

1. Arnavas, Donald P. and William J. Ruberry. <u>Government Contract Guidebook</u>. Washington DC: Federal Publications Inc., 1987.

2. "The Buying Process," Class Handout from CMGT 524, Contracting For Engineers, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, April 1991.

3. Chambers, Robert W, Peace Shield Inspection and Engineering Services Program Director and Vice President, 3D/International. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 5 April 1991.

4. -----. Peace Shield Inspection and Engineering Services Program Director and Vice President, 3D/International, Personal interview. HQ AFLC, Wright-Patterson AFB OH, 3 Jul 1991.

5. Cole, J. B., Director of Construction and Environmental Services. Personal interview. HQ USAF, Washington DC, 29 April 1991.

6. -----. "The New MILCON Process," Address to the MGT 422, Project Management Course. School of Civil Engineering and Services, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, 29 April 1991.

7. Cook, Thomas M. and Robert A. Russell. <u>Introduction to Management Science</u>. New Jersey: Prentice Hall, 1989.

8. Cullin, William H. <u>How to Conduct Foreign Military Sales: The United States Guide</u>. The Bureau of National Affairs, Inc., Washington DC, 1984.

9. Defense Institute of Security Assistance Management. <u>The Management of Security Assistance: Tenth Anniversary Edition</u>. Wright-Patterson AFB OH, April 1990.

10. -----. <u>The Management of Security Assistance: Eleventh Edition</u>. Wright-Patterson AFB OH, April 1991.

11. Defense Security Assistance Agency. <u>Security Assistance Management Manual</u>. DOD 5105.38-M. Washington: 1 March 1991.

12. Department of the Air Force. Combat Air Base Performance Planning: Volume 1 (Draft). AFM 3-C. Washington: HQ USAF, July 1991.

13. -----. Security Assistance: Security Assistance Management. AFR 130-1. Washington: HQ USAF, 6 November 1987.

14. Directorate of FMS Construction. Foreign Military Sales Construction. Brochure for DCS, Engineering & Services, Air Force Logistics Command, Wright-Patterson AFB OH, 24 October 1990.

15. "Draft Trip Book for Maj Gen Ahearn, HQ USAF/CE," Air Force FMS Construction Engineers. HQ AFLC, Wright-Patterson AFB OH, June 1991.

16. "Egyptian FMS Program Notebook," Egyptian Division, Air Force FMS Construction Engineers. HQ AFLC, Wright-Patterson AFB OH, Jun 1991.

17. Glardon, Thomas L. Resolution of Organizational Conflict Between Base Civil Engineering and Base Contracting. MS Thesis, AFIT/GEM/DEM/90S-8. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1990 (AD-A229552).

18. Graves, Ernest and Steven A. Hidreth. U.S. Security Assistance: The Political Process. Massachusetts: Heath and Company, 1985.

19. Guirguis, Amir A., Program Manager, Egyptian Division, Air Force FMS Construction Engineers. Personal Interview. HQ AFLC, Wright-Patterson AFB OH, 16 July 1991.

20. Harris, Patrick R., Peace Shield Coordinator. Personal Interview. CRSS + M&E Joint Venture, Wright-Patterson AFB OH, 26 July 1991.

21. Hayes-Roth, Frederick, Donald A. Waterman, and Douglas B. Lenat. Building Expert Systems. Reading Mass: Addison-Wesley Publishing Company, Inc., 1983.

22. Heery, George T., Charles B. Thomsen, and Clifton D. Wright, Bridging: A Report to the U.S. Air Force on Planning, Programming, Design, Contracting and Construction with Recommendations. 3D/International & Brookwood Group. 2 May 1991.

23. Hensley, James H., Program Manager, Saudi Arabia Division, Air Force FMS Construction Engineers. Personal interviews. HQ AFLC, Wright-Patterson AFB OH, 25-26 July 1991.

24. -----. Program Manager, Saudi Arabia Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 30 July 1991.

25. -----. Program Manager, Saudi Arabia Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 6-16 August 1991.

26. Jageman, George J. Jr., Area Engineer, Wright-Patterson Area Office. Personal interview. US Army Corps of Engineers, Louisville District Construction Division. Wright-Patterson AFB OH, 23 July 1991.

27. Malik, Anwar. Executive Secretary, Deputy Program Director for Peace Shield, Telephone interview. CRSS + M&E, Riyadh Saudi Arabia, 16 July 1991.

28. Melendrez, Frank Jr., Program Manager, Egyptian Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 6 June 1991.

29. "MILITARY CONSTRUCTION PROGRAM Student Outline Guide," Class handout distributed in MGT 422, Project Management Course. School of Civil Engineering and Services, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, 29 April 1991.

30. Miller, Ronald B., Peace Shield Inspection and Engineering Services Civil Design Engineer. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 7 June 1991.

31. Myers, William R., Deputy Director, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 19 April 91.

32. -----. Deputy Director, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 9 July 1991.

33. -----. Deputy Director, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 18 July 1991.

34. -----. Deputy Director, Air Force FMS Construction Engineers. Telephone interview. HQ AFLC, Wright-Patterson AFB OH, 24 August 1991.

35. ----- and Kenneth C. Wichman. Deputy Director, Air Force FMS Construction Engineers and Chief, Saudi Arabian Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 1 March 1991.

36. Osgood, Douglas C. Civil Engineering Guide to the Acquisition Regulations: Nineth Edition. The School of Civil Engineering and Services, The Air Force Institute of Technology, Wright-Patterson AFB OH, October 1990.

37. "POM CYCLE handout," MGT 422, Project Management Course. School of Civil Engineering and Services, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, 29 April 1991.

38. "Project Delivery Strategy," MGT 422, Project Management Course. School of Civil Engineering and Services, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, 29 April 1991.

39. Rice, Donald B. The Air Force and U.S. National Security: Global Reach - Global Power, A White Paper. June 1990.

40. Rothenberg, Col Karsten H., Director, Air Force FMS Construction Engineers. Personal Interview. HQ AFLC, Wright-Patterson AFB OH, 11 July 1991.

41. Sawyer, Michael J., Program Manager, Saudi Arabia Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 15 August 1991.

42. Schmidt, Lt Col Michael H., Chief, Programs Division, Air Force FMS Construction Engineers. Personal Interview. HQ AFLC, Wright-Patterson AFB OH, 10 March 1991.

43. -----. Chief, Programs Division, Air Force FMS Construction Engineers. Personal Interview. HQ AFLC, Wright-Patterson AFB OH, 7 May 1991.

44. Tandy, Donald F., Chief, Egyptian Division, Air Force FMS Construction Engineers. Personal Interview. HQ AFLC, Wright-Patterson AFB OH, 9 July 1991.

45. USAF Project Manager's Guide for Design and Construction. Washington DC, USAF/LEE, June 1989.

46. Waterman, Donald A. A Guide to Expert Systems. Reading Mass: Addison-Wesley Publishing Company, 1986.

47. Wichman, Kenneth C., Chief, Saudi Arabian Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 17 July 1991.

48. -----. Chief, Saudi Arabian Division, Air Force FMS Construction Engineers. Personal interview. HQ AFLC, Wright-Patterson AFB OH, 6 August 1991.

49. -----. "Point Paper on Peace Shield." Air Force FMS Construction Engineers. HQ AFLC, Wright-Patterson AFB OH, 29 May 1991.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE: SEPTEMBER 1991

3. REPORT TYPE AND DATES COVERED: MASTER'S THESIS

4. TITLE AND SUBTITLE: BUILDING A FOREIGN MILITARY SALES CONSTRUCTION DELIVERY STRATEGY DECISION SUPPORT SYSTEM

5. FUNDING NUMBERS

6. AUTHOR(S): DEVEN R. VOLK, CAPTAIN, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES): AIR FORCE INSTITUTE OF TECHNOLOGY, WPAFB, OH 45433

8. PERFORMING ORGANIZATION REPORT NUMBER: AFIT/GEM/DEV/91S-15

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT: APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words) This research builds a Decision Support System to help Air Force Logistics Command, Foreign Military Sales construction managers select a construction delivery strategy in support of weapon system sales to foreign countries. Delivery strategy options include the Corp of Engineers, Naval Facilities Engineering Command, private industry Architectural Engineering firms, the weapon supplier, or the foreign country purchasing the weapon system. The parameters upon which the selection is made are program schedule, staffing requirements, weapon system development stage and design complexity, type of contract strategies selected, a customer assessment of foreign country requirements and existing conditions, and the ability to respond to construction program changes. The research discovered that as the program schedule is shortened, all parameters take on more critical characteristics. As the program schedule becomes longer, the parameters take on characteristics of standard construction practices. In the latter situation, more complex construction technology requirements may be prevalent in pushing the situation away from standard. Air Force policy supports the use of the COE or NAVFAC under more standard conditions. As conditions become less standard, private industry is preferred.

14. SUBJECT TERMS: Foreign Military Sales, Foreign Military Sales Construction, Construction, Middle East Construction

15. NUMBER OF PAGES: 124

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

AFIT Control Number AFIT/GEM/DEV/91S-15

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: AFIT/LSC, Wright-Patterson AFB OH 45433-6583.

1. Did this research contribute to a current research project?

   a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

   a. Yes b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Please estimate what this research would have cost in terms of manpower and/or dollars if it had been accomplished under contract or if it had been done in-house.

   Man Years ______________ $______________

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

   a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments

______________________ ______________________
Name and Grade Organization

______________________ ______________________
Position or Title Address